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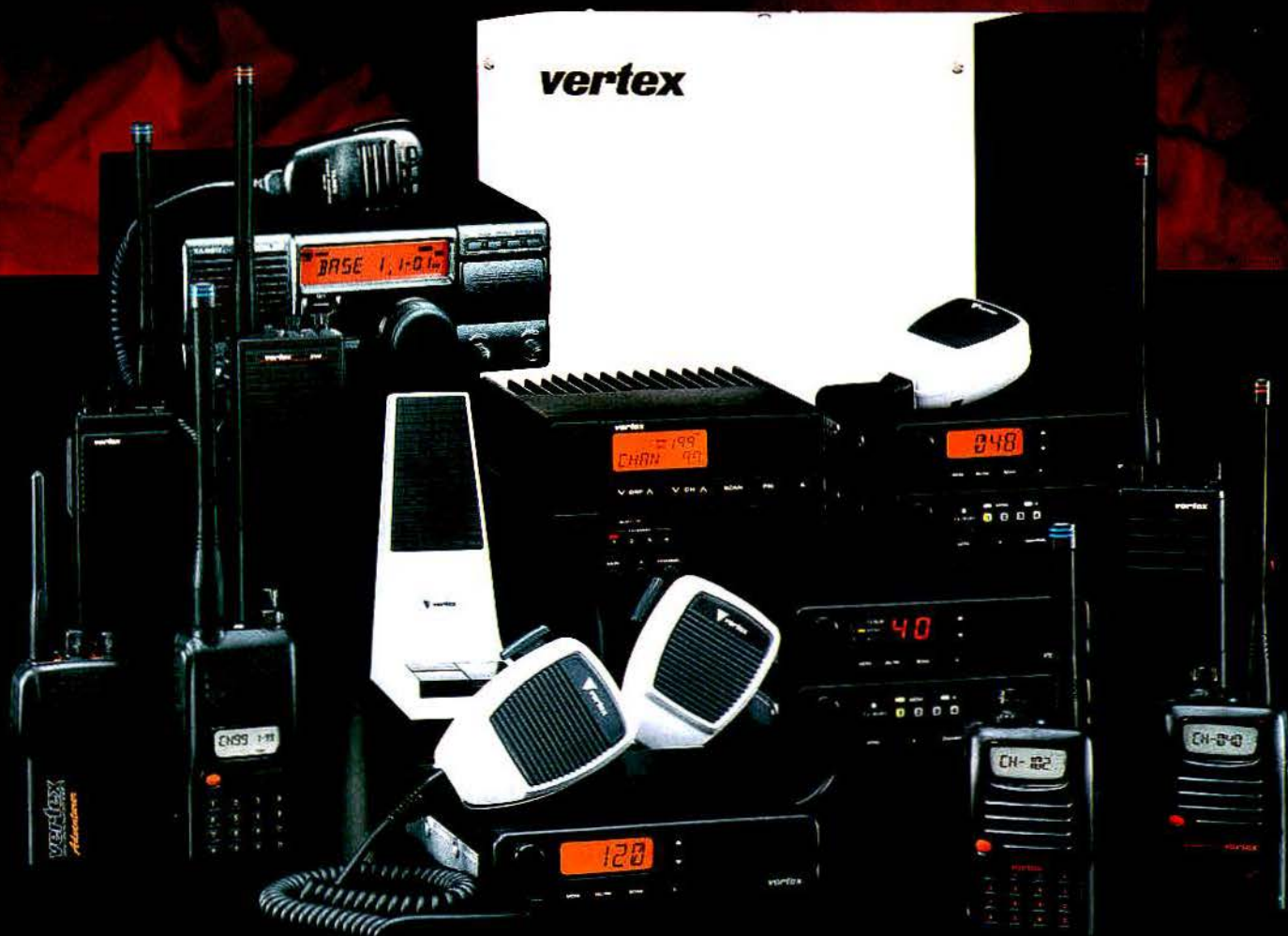
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E.F. Johnson sends a clear signal about Project 25.

Our position is clear: Nobody knows better how public safety communications should work than the people who use it. These dedicated professionals have spent nearly a decade shaping their vision of how public safety communications will work in the future—the APCO-initiated Project 25 suite of standards. E.F. Johnson respects and applauds their efforts.

Our commitment is firm: E.F. Johnson Company is redoubling its commitment to Project 25. We were an original signatory to the Project 25 process. We were one of the first manufacturers to publicly demonstrate P25 Common Air Interface products. We're already the #2 manufacturer of Project 25 conventional products. And now, E.F. Johnson:

- Has just released System 3 trunking radios with 3600 bps P25 CAI.
- Will roll out additional Project 25 trunking terminals and infrastructure products.
- Supports Project 25 for the new 700 MHz band.

It's your choice: This is not the time for quick fixes or wireless technology that's unfamiliar and unproven in U.S. public safety applications. Public safety communications provide a lifeline that thousands of law enforcement officers, firefighters, and paramedics depend on every day.

The Project 25 standards are *your* standards, developed by you and your APCO colleagues. E.F. Johnson stands with you, remaining firmly committed to the goal of interoperable public safety communications across the U.S.—the goal of Project 25.



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October 2000

On the cover: A project to supply noise-canceling headsets with boom microphones for firefighters in South Carolina is described in "Technically Speaking" on page 18. Cover design by Scott Dolash, art director. Photo courtesy of South Carolina Forestry Commission.

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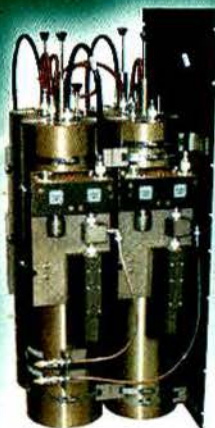
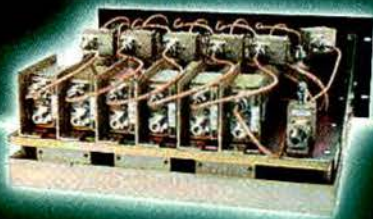
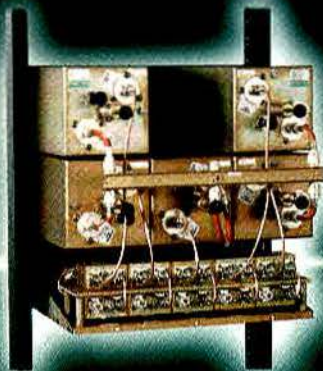
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What's the TETRA and Project 25 flap all about?

Hardly anyone who has something to do with public safety communications agrees about anything when it comes to TETRA's features and capabilities vs. those of Project 25, the definition of "interoperability," the standards-setting process, and who has to license TETRA intellectual property rights and why and when and for what. Ready? Let's begin:

The "Project 25" U.S. standard for public safety digital radio may be the best chance to achieve interoperability among federal, state and local jurisdictions for services that protect life and property.

Interoperability is so important that some detest the idea that at this late date TETRA, a competing digital technology from Europe, might enter the field if it isn't modified for interoperability—whether some potential users want it modified or not.

Interoperability proponents have federal support. The FCC may require the use of Project 25 equipment in the new 700MHz public safety band.

European interoperability

Europe can achieve public safety and commercial interoperability throughout the continent on its new private mobile radio service band (380MHz–400MHz) and its commercial mobile radio service band (410MHz–430MHz), among other frequencies. The fastest-growing interoperable systems use a European standard originally called Trans-European Trunked Radio and renamed as Terrestrial Trunked Radio (TETRA). Yet, a competing, non-compliant digital technology has won 500,000 users in Europe and elsewhere, and it is not interoperable with TETRA. More about that later.

Some European governments interpret a European Union Treaty provision as requiring them to deploy *only* TETRA. In 1996, the United Kingdom's Home Office limited bids for its national police and emergency service network to TETRA suppliers. It awarded the \$2.1 billion contract to British Telecom.

Matra Nortel, the French manufacturer of TETRAPOL, the competing and similarly named—though fundamentally different—digital technology, is challenging the exclusive procurement of TETRA and has some support from the European Commission. Matra Nortel argues that TETRAPOL's frequency-division, multiple-access (FDMA) technology is "equivalent" to the TETRA standard. As such, the company argues that government contractors must evalu-



ate their tenders or they would breach European Union Treaty rules on the free movement of goods and services.

Despite separate European and U.S. decisions that favor interoperability with home-grown standards, some European manufacturers want the North American market opened up.

The interesting twist to all of this involves the different performance and capacity of time-division, multiple-access (TDMA) and FDMA technologies. TETRA is TDMA; Project 25 (Phase I) and TETRAPOL are FDMA.

Europe is more densely populated than the United States. It has few areas of sparse population as compared to our western states. Most of its public safety agencies, especially police departments, are organized into larger departments at federal and state levels. It doesn't have the many small municipal departments (those with only a few officers) that are common in this country.

This difference is important because a persuasive case has been made that FDMA serves small user groups and sparsely populated areas better, in part because it can be implemented with

fewer channels when a small system fits the need. TETRA produces the equivalent of four channels in a 25kHz bandwidth as a minimum. Its infrastructure may require more sites for equivalent coverage to FDMA. TETRA reuses frequencies in multisite networks (and thus, might need more frequencies), either reducing the need for simulcast or compensating for its inability to simulcast, depending on how you look at it.

Which is better—and why?

According to an older report written by an ETSI working group, for fewer than 10 channels per site and wide-area coverage, FDMA is superior. For more than 15 channels per site and limited area coverage, TDMA is superior. Even so, systems with few channels and increasingly sophisticated data applications could benefit from TETRA's ability to aggregate, on demand, four time-slots for 28.8kbps "high-speed" data capability.

Some U.S. jurisdictions are densely populated and have large public safety agencies. Several European-based manufacturers want to offer TETRA to them.

These manufacturers want to serve U.S. commercial users, too. TETRA was designed with public safety and commercial users in mind; Project 25 was not.

TETRA can be modified to fit Project 25's Phase II 6.25kHz-and-equivalent narrowband standard. Committees involved with the standard have begun working on the modification. Commercial users don't need the modification.

Manufacturers would rather not modify their products, in part because it will raise the price. The difference in price between FDMA and TDMA products is expected to be a key selling point.

With respect to public safety, it will come down to individual agencies making their own radio communications system procurement decisions based on what's most important to their operations. If some forgo interoperability, it will be despite every effort being spent to make it available.

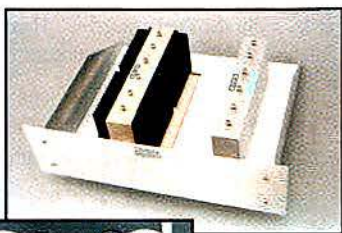
Don Bishop

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don_bishop@intertec.com

For the news story about manufacturers' efforts to bring TETRA to North America, log on to www.mrtmag.com. The site is about to be upgraded. If the "Online Extras" button is still there, click on it for the story.

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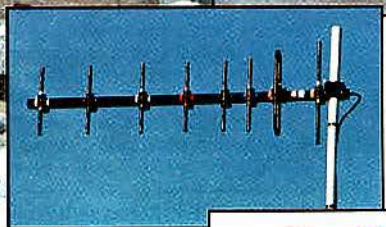
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PLUS: Robert H. Schwaninger Jr.'s "In the Public Interest"; Harold Kinley's "Technically Speaking"; David Dunford's "Public Safety: '10-2'"; editorial commentary from Don Bishop and David Keckler; Product focus—what's new in field testing equipment.

AND IN THE MONTHS TO COME:

Buyers' Guide; TETRA; headsets; towers; base station antennas; IWCE preview; resolving interference.

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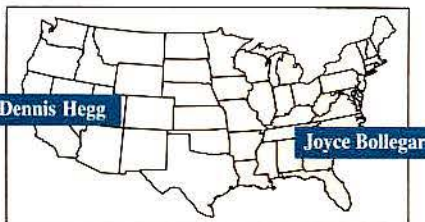
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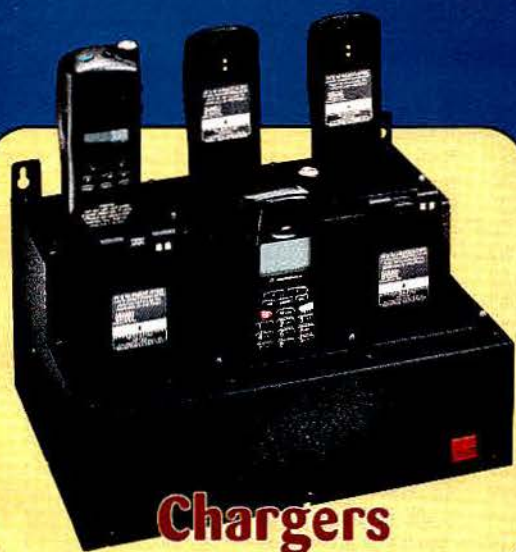
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15-17: ENTELEC & UTC Joint 2000 Fall Seminar, sponsored by ENTELEC and UTC, Houston. Contact: 888-503-8700 or email entelec@pdq.net.

23-25: AMTEX, sponsored by the American Mobile Telecommunications Association, Embassy Suites Outdoor World, Dallas. Contact: 202-331-7773 or www.amtausa.org.

29-Nov.1: Tower Summit, sponsored by Shorecliff Communications, The Paris Hotel, Las Vegas. Contact: 888-662-6021 or www.scievents.com.

November

5-7: Utilities Telecom Summit, sponsored by UTC, the United Telecom Council, Sheraton Bel Harbour, Miami Beach, FL. Contact: 202-872-0030 or www.utc.org.

6-8: IEEE-APS Conference on Antennas and Propagation for Wireless Communications, cosponsored by the IEEE Vehicular Technology Society, Westin Hotel, Waltham, MA. Contact: 781-890-5290 or www.ecece.unm.edu/apwc2000.

12-15: Telecommunications Resellers Association Fall Conference and Exhibition, sponsored

by TRA, Anaheim, CA. Contact: 202-835-9898 or www.tra.org.

15-18: Communications Marketing Conference, sponsored by the Communications Marketing Association, Sheraton Colony Square, Atlanta. Contact: 404-892-2600, ext. 300 or www.commktga.com.

17: Radio Club of America Communications Symposium, 92nd Anniversary Dinner and Awards Presentation, New York Athletic Club, New York. Contact: Gerri Hopkins, 732-842-5070.

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February

20-23: NATE, sponsored by the National Association of Tower Erectors, Adam's Mark Hotel, Dallas. Contact: 888-882-5865 or www.natehome.com.

March

20-22: Wireless, sponsored by the Cellular Telecommunications Industry Association, Las Vegas. Contact: 202-785-2842 or www.wow-com.com.

28-30: International Wireless Communications Expo, sponsored by *Mobile Radio Technology*, Las Vegas Convention Center, Las Vegas. Contact: Web site www.iwceconexpo.com.

April

1-4: ENTELEC, sponsored by ENTELEC, New Orleans. Contact: 281-357-8700 or Web site www.entelec.org.

May

6-9: Spring Vehicular Technology Conference, sponsored by the IEEE Vehicular Technology Society, David Intercontinental Hotel, Tel Aviv, Israel. Contact: 972-3-6133340 or www.congress.co.il/ieee_new/index1.html.

21-24: Telecommunications Resellers Association Spring Conference and Exhibition, sponsored by TRA, Adam's Mark Hotel, Dallas. Contact: Web site www.tra.org.

June

3-7: Supercomm, sponsored by TIA and USTA, Georgia World Congress Center, Atlanta. Contact: 800-278-7372.

24-27: UTC Telecom, sponsored by UTC, the United Telecom Council, Midwest Express, Milwaukee. Contact: 202-857-1881 or www.utc.org.

24-28: NENA, sponsored by the National Emergency Number Association, Orlando, FL. Contact: Web site www.nena9-1-1.org.

August

5-9: Association of Public-Safety Communications Officials—International (APCO) National Conference, Salt Lake City. Contact: 904-322-2500 or www.apco-intl.org.

September

11-14: PCIA GlobalXChange, sponsored by the Personal Communications Industry Association, Los Angeles Convention Center, Los Angeles. Contact: 703-739-0300 or www.pcia.expoventure.com.

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Glad I made it

Murphy's Law had me firmly in its grip this year on my way to APCO. In fact, it probably terrorized several travelers this year with ever-increasing canceled flights and delays. My flight to Boston was canceled, stranding me in Chicago, and when I called my hotel to tell them I'd be late, my room had been canceled. (Don't ask me why.) They could accommodate me for that one night, however.

I finally arrived in Boston about 10:30 p.m., and United was only operating one small luggage belt, which was hav-

ing mechanical problems. So I stood around the luggage belt with passengers from three other full flights for an hour and a half.

I was relieved when at about midnight, my bag showed up. I don't know what flight it came in on, but at least it was there. I snatched it up and headed for the taxi stand. But the line for taxis stretched along the building as far as I could see

The next morning, the concierge called my room and said the hotel could not extend my stay. So, the only thing I could do was get up and go to the conference.

Guess what? Registration couldn't find my name when I went to pick up my badge. (It just follows with the rest).

Other than that, APCO was a success this year (I *did* get in). The good nature of the attendees and exhibitors quickly brought me out of my self-pity. (Several people offered to share their rooms with me.) The convenience of the Hynes Convention Center made up for the other inconveniences. The number of booths was tremendous—too many to visit, but public safety communications officials could easily find something they were looking for.

The FCC even participated in APCO this year to a larger extent than I've seen before. Commissioner Gloria Tristani gave the keynote address, and Thomas Sugrue and D'Wana Terry of the Wireless Telecommunications Bureau participated in a regulatory Q & A panel.

One of the big questions was regarding the encumbered nature of the 700MHz band. The year 2006 is a long way away, and no one could seem to tell us if the band was going to be cleared any earlier than that. My magic eight-ball says, "Outlook not so good." Tristani herself said, "We will need to find additional spectrum to carry forward the public safety mission."

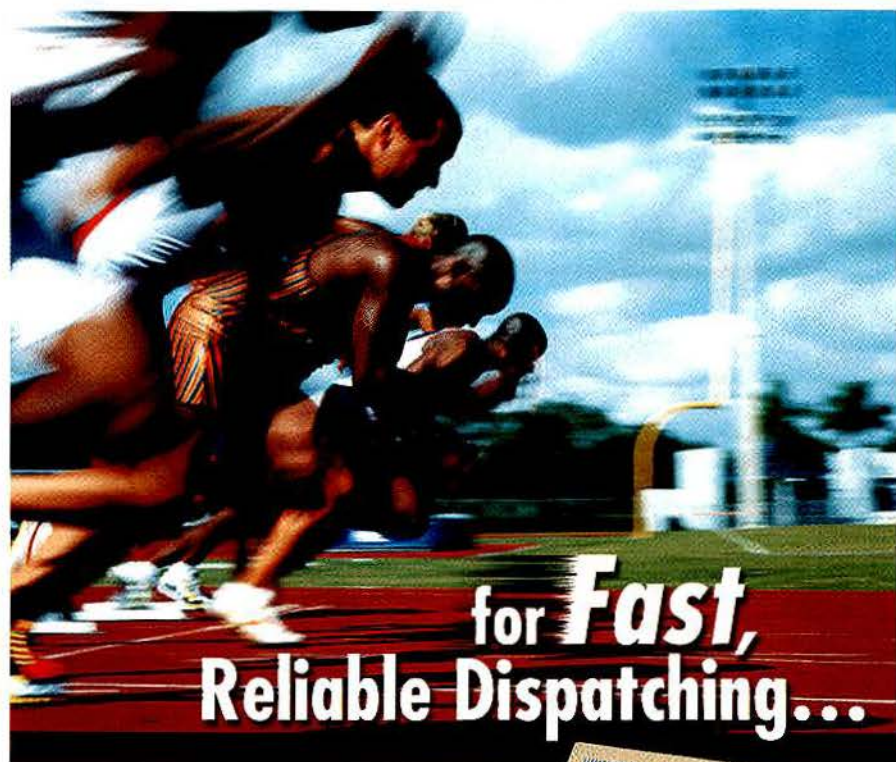
Other important issues were covered all over the conference, on the show floor and in sessions, such as the arrival of TETRA, 800MHz interference, 9-1-1 issues, convergence and voice over IP.

All in all, when I asked the magic eight-ball if I would ever have such an experience again, it answered, "Cannot predict now."

—Nikki Chandler

Senior Associate Editor

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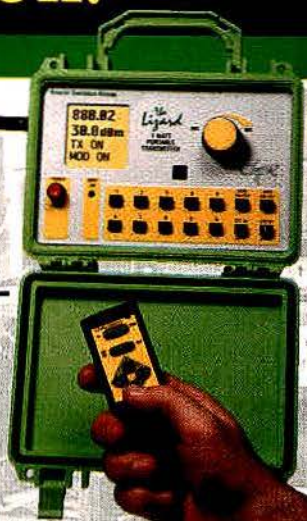


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Coin-flip candidacy

By Robert H. Schwaninger Jr.

With the increasing flow of rhetorical rhubarb filling our TV sets as political parties begin posturing for our favor, it behooves us to take the time to consider our choices. After all, we live in a republic that favors regulation, taxation and telecommunications—when the carrier is colossal. Thus we are directly affected by the policies of the White House occupant. Who gets the keys to the mansion must then concern us.

First, there is the smirky and apologetically smarmy entrant from Texas, who has tried to assert that his acumen is not an issue and that his choice for veep is not a throwaway. We are attracted to his easy style and the confidence that his contributors have shown. However, we note that his party's congressional record is replete with auctions, mega-mergers and diminishment of the effectiveness of the antitrust laws.

Second, there is the stiff from Tennessee, who has participated in shaking down nuns for political contributions while his wife rails against dirty lyrics on rock songs. We are attracted to his forthright posture, yet we cannot reconcile it with his record. However, we note that his party gave us the likes of Reed Hundt, which was akin to inviting Freddie Krueger to remove a sty.

This choice isn't going to be easy. Each of the candidates has so little going that the race appears to be between treed political possums, pulling hand-over-tail toward the silver chalice of victory that is awarded to the least self-destructive.

Schwaninger, MRT's regulatory consultant, is the principal in the law firm of Schwaninger & Associates, Washington, which is counsel to Small Business in Telecommunications. Schwaninger is also a member of the Radio Club of America.

And each mandate-seeking marsupial has upon his back a veep-baby who is trying to help, but still must be carried.

The Texan has teamed with the Wyoming war wonk, who attempted to identify a Mideast victory as a no-fly zone, while an oily tin dictator thumbed his nose across the designated parallels. We

a clue. My experience with both sides of the aisle is wholly inconclusive and my guess as to which form of abuse is worse is only that: a guess. So ask yourself these questions:

Q1: Do you believe that Congress should be entitled to judge the eligibility of persons seeking to construct and operate

radio systems purely on the basis of auction receipts?

Q2: Do you believe that all persons who hold an FCC license should chip in to buy computer systems for every school child in America, regardless of the size or resources of the licensee?

Q3: Do you think it is impossible for public safety to ever have enough spectrum to operate its systems, therefore, government should find more and more channels for this purpose?

Q4: Does your mind go totally blank when you hear the words "business and industrial radio" so that any phrase said thereafter sounds like "wa-wa-wa-wa...." (Think Charlie Brown's teacher)?

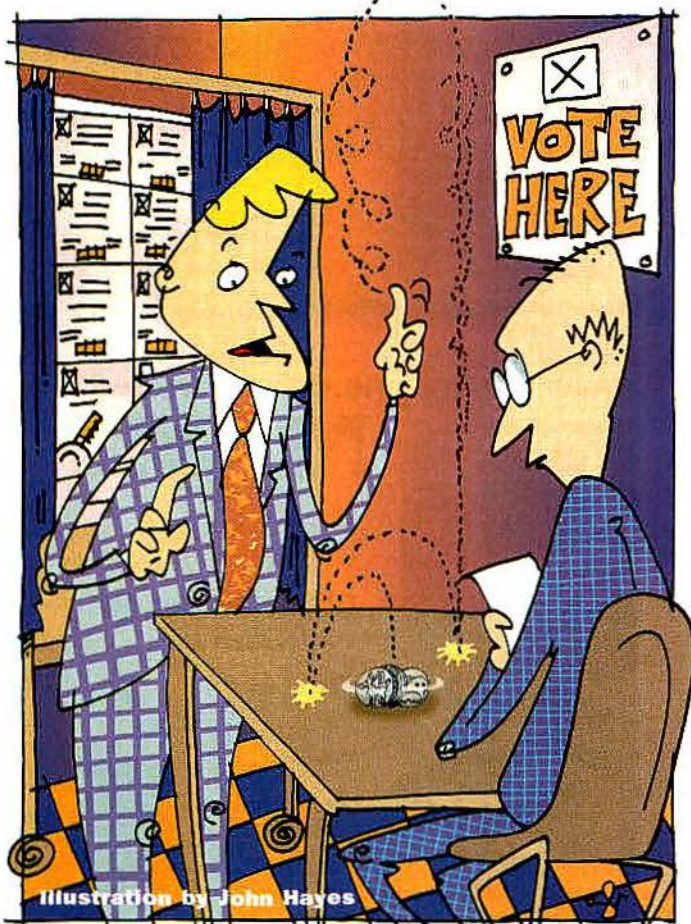
Q5: Do you think that the most important duty of every politician is to get reelected?

Q6: Do you believe that when in doubt, Congress should ask the broadcasters what to do with spectrum?

Q7: Do you support the ban on auctions of spectrum for operation of broadcast stations, cable television stations, LEC authority and every other kind of use—except land mobile radio?

Q8: Have you ever found yourself covering up an affair while denouncing someone else for their unholy infidelity?

If you answered in the negative to each question posed above, you have provided yourself with *no guidance whatsoever* in the upcoming election for top executive. Each of the questions would, if answered honestly, receive a resounding "Yes!" from Democrats and Republicans. Even the Green Party would sell land mobile spectrum. They'd just use the proceeds to



"No matter how many times I flip it, it keeps standing on the edge."

could have "bought" Iraq with another two-weeks of firepower. Instead, we decided to lease a right-of-way with no end to the terms of the agreement.

The Tennessean linked up with the Connecticut reformer, who admonished President Clinton for his escapades from the floor of the U.S. Senate. He denounced the randy guy from Hope, AR, then hooked up with Slick Willie's underboss. I'm not sure how that works.

So, who do you vote for? I haven't got



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WITH SEPARATE VOLT & AMP METERS

MODEL	CONT. (Amps)	ICS	SIZE (inches)	Wt.(lbs.)
SRM-25	20	25	3 1/2 x 19 x 9 1/4	6.5
SRM-30	25	30	3 1/2 x 19 x 9 1/4	7.0

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MODEL	CONT. (Amps)	ICS	SIZE (inches)	Wt.(lbs.)
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CIRCLE (12) ON FAST FACT CARD

extend the school lunch program to cover feeding spotted owls.

So, what am I going to do? This quandary resurfaces every four years to mock and beguile me. One siren calls to the right and the other to the left, both luring me toward the rocky shoals of partisanship while dashing my hopes on the shores of uber-political greed and expediency.

My patriotism is challenged and my sense of duty beckons me toward the polling booth while my stomach tightens. Standing before the levers that will mark my choice, I will pause—because I am not convinced. I am not comfortable. I am torn between the desire to “waste” a vote by writing in the name of someone I deem more worthy of responsibility and the knowledge, but knowing that this honest act is a silent one, unseen to all, and will not change a digit in the tabulated outcome.

With quiet deliberation, I decide what course to take, and it is a two-handed effort, employing both the left and the right wings of my body as symbols of my political leanings, which resemble more a willow in a storm than a stanchion of one-sided conviction.

With one wing I reach up and slowly pull the lever that will mark my participation in this most noble of patriotic acts. And with the other wing I will reach

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CIRCLE (13) ON FAST FACT CARD



up and pinch my nose to record my opinion of the primary system's failings that has caused these two packaged players to be pushed onto the public.

What price democracy? What price freedom? What a coin flip of conscience that has me wanting to climb under my bed, assume the fetal position and cover my tired eyes. I haven't felt this way for four years. ■

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Circle (14) on Fast Fact Card

Why things go wrong...

...and why they stay that way

By David O. Dunford

Years ago, we were studying hyperbolic functions in Mr. Smith's algebra class when he related a story about the application of *limit theory*. The story explains that if a boy and a girl are facing each other 100 feet apart and then move toward each other in a sequence of steps, each step being one-half the remaining separation, that they will never actually touch but will be close enough for "all practical purposes."

In public safety communications, it seems that system construction and project management often suffer the same fate. Our work product may not be complete, but it usually gets "close enough" for all practical purposes. There are a variety of unseen effects and uncontrollable (or at least *unexplainable*) external forces that seem to affect this process of incremental system improvements, which we call a "project," and I hereby offer several observations for the non-public safety reader, hoping to provide insight into our collective plight.

First, we're part of *government*. That means we're accountable for our actions and every dollar spent. To exceed the budget is an unpardonable sin. (Many years ago, civic volunteers in a neighboring city held a pancake breakfast, the profits from which were used to purchase two PTT foot pedals, one for each of their department's two new radio consoles. Discretionary budget funds available? I don't think so.)

Another story, which should also be near to Radioman's heart, involves a community whose police chief had a flawed understanding of radio equipment: He earnestly believed that "solid state" actually meant "never needs replacement"—and the HT-200's hadn't been. In all cases, the users must live with the effects, good or bad, of this

governmental process.

Suppose that we actually get a project budget moving and a groundswell of support behind the effort—what next? (Note: a *groundswell* is a city council member hearing from one constituent.) The first thing on the agenda is usually a "needs assessment," which is the name given to a list of problems everyone has known about for several years. Next comes "system design," which is the name given to a list of improvements



that everyone, except the consultant, has known about for several years. Then comes the real art in public safety communications system projects: accurately estimating a budget figure. As system managers, we must remember that the budget may take some time to get approved and that not everyone likes pancakes for three meals a day.

Being a public safety user in a world of commercial providers can also put us at a disadvantage. Negotiating for rooftop antenna space, or an entire tower site, in an environment driven by free-market forces can quickly deplete a local community's rental budget. A lowband antenna atop an RF-noisy grain elevator isn't always an acceptable al-

ternative, either. Our collective posture as "the good guys" doesn't carry much weight with a sharp-nosed real estate agent or a distant tower rental rep. Also, most agencies don't have the benefit of a Washington attorney to help them wade through licensing snags or FCC paperwork and processing snafus. (Note: The low-frequency hum you hear through the phone when actually speaking with these fellows in the rarefied Potomac atmosphere is really just the meter running.) One effect of this entire "government process" is that siting errors may not be readily corrected. If we initially "guess" wrong about antenna

placement or tower siting (engineers call this a "propagation prediction anomaly"), we might be stuck with a five-year lease period during which to contemplate our alternatives.

One option is to contract with an engineering consultant as part of system planning. But the engineer's bent for excruciating detail can create a professional services contract that makes the actual site lease look like an I.O.U. stuffed inside a Coke machine. Two agencies once embarked on a joint, slow-growth 800MHz trunking system that was planned as a single-site system. I discussed with the consultant a known "dead spot" several miles from the site, and his reply was that the problem would

be solved by "creative engineering." The final solution actually required "creative financing." (See budget options, above.)

These are only a few of the pitfalls (and pratfalls) public safety professionals face in shepherding along a project, and we haven't even talked about computer consultants or integrated AVL-CAD systems. I laud each of you for your efforts—but mostly for your persistence. ■

Dunford, MRT's public safety consultant, is manager of technical services for the Lenexa, KS, police department. He is a member of the Association of Public-Safety Communications Officials-International. [You can email him at mrt@intertec.com.]

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Understanding wireless communications in public safety

Concluding excerpts from a guidebook to technology, issues, planning and management for public safety communications professionals.

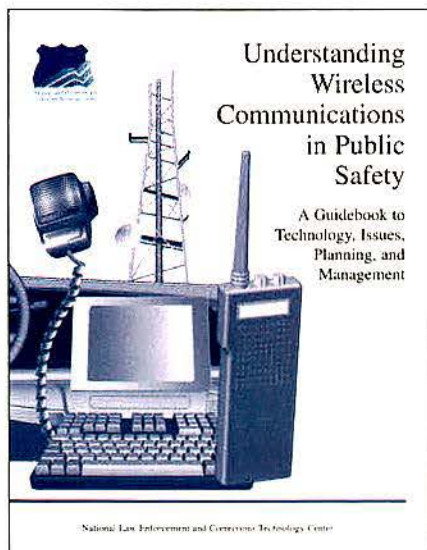
This month: Wireless communications options.

By Kathy Imel and James W. Hart

Editor's note: Through the National Law Enforcement and Corrections Technology Center—Rocky Mountain Region (NLECTC—RM), a program of the National Institute of Justice, authors Imel and Hart have prepared a guidebook to help both new and experienced public safety communications managers over the hurdles of system procurement and operations.

The September issue of MRT presented excerpts from Part 1 of that 135-page book concerning "Planning and managing a communications project." Parts 2 and 3 discuss "Wireless communications technology" and "Wireless communications issues," respectively. This month we conclude our excerpts with a look at Part 4—"Wireless communications options," which discusses voice system options, data system options and the latest developments in communications technology.

The target audience for this guidebook consists of those middle and upper managers who are responsible for funding and/or managing communications at their agencies, but who have little or no technical background in wireless technology. Information on obtaining a copy of the complete work appears in the authors' credit.



Weighing your options

This section looks at the options public safety agencies have for wireless communications, including the purchase of their own radio components and systems. The authors also have included examples in which local governments have used commercial services.

One special case is described in which a tower and radio supplier provided radio communications to a town by entering into an agreement to use some of the town's high-elevation real estate for commercial radio development in return for dedicated government radio systems. Examined are the many commercial voice and data services available to law enforcement, including cellular and PCS, CDPD, SMR/ESMR and data networks.

Networks are complicated. They consist of three generic components: hardware, software and middleware. Hardware consists of radios, modems and laptop computers; software is the programming that runs the radio controllers, modems, and laptop computers; and middleware is the (software) glue that interconnects all the components. Middleware must be selected that supports the required hardware and software protocols.

► **A reminder** — All radio systems should be carefully checked to make sure they have the coverage you need. If you are purchasing a new system, make sure that the supplier gives you written assurances that the system meets your needs. If you need to communicate with hand-held radios in reinforced concrete buildings, make sure the supplier knows and makes calculations taking that into account. There are independent consultants who also can perform these calculations if you need a verification check. If the radio network is already con-

structed, borrow or rent equipment from the supplier and make sure the coverage satisfies your requirements.

Dedicated radio systems

Dedicated public safety radio systems include all radio technologies, ranging from conventional FM simplex and repeater systems to complex and expensive trunked wide-area analog and digital radio systems at all of the two-way frequencies.

There are many suppliers for public safety radio systems. Three companies, however, have supplied and continue to supply the majority of public safety radio systems: Motorola, Com-Net Ericsson, and the E.F. Johnson division of Transcrypt.

The three major companies had representatives on the Project 25 committee, which selected the first-phase digital trunked system technology standard to carry public safety communications into the next century. The Motorola protocol was selected for the first phase, and Motorola has offered its intellectual properties, royalty free, to other suppliers to allow competition. A large number of suppliers are developing systems using the new standard.

There are many other smaller suppliers of FM equipment, and some are supplying narrowband systems for the 220 MHz frequency band.

Sample vendors

► **Motorola** — Motorola offers some

Imel is president of La Loba International. Hart is president of Hartech.

Imel's email address is kjmel@aol.com. Hart's email address is jhart@du.edu.

Complete print copies of this book can be ordered for free from NLECTC at 800-248-2742. It can also be downloaded as a PDF file from the NLECTC Web site: www.nlectc.org/pubs/#comm.

sophisticated digital radio networks, as evidenced by its Smartzone system, which can be configured for conventional repeaters, single or multiple site trunked repeaters, and/or simulcast trunked repeaters. The company is currently upgrading the radio and dispatch systems for the city of Los Angeles.

► **Com-Net Ericsson Critical Radio Systems** — In January 2000, Ericsson announced it was selling its private radio systems operations to Com-Net Critical Communications, with the company renamed Com-Net Ericsson Critical Radio Systems. Com-Net Ericsson's main line of equipment for public safety is its enhanced digital access communications system (EDACS). EDACSs are used in trunked repeater systems including wide-area simulcast coverage. Com-Net Ericsson has stated recently that it will begin to address and manufacture more conventional radio system products tailored toward the small law enforcement agencies around the world.

► **E.F. Johnson Division of Transcrypt** — Transcrypt offers both conventional and trunked analog and digital radio systems on all the two-way frequency bands through its LTR product line. It also offers Project 25-compliant radios for public safety requirements.

Advantages of dedicated systems

- ❑ Public safety entities may generate specifications to meet their exact system needs. They have complete control of the design and operations.
- ❑ As part of the tailoring, the priority of use may be established within the entity.
- ❑ Combined dedicated radio systems (i.e., shared with other communities) may save considerable investment and still preserve the tailoring at a more reasonable cost per agency.

Disadvantages of dedicated systems

- ❑ The capital outlay may be quite high and prohibitive for a small- to medium-size community.
- ❑ The owner of the system must pay for all maintenance and improvements.

Cellular and PCS radio

Many law enforcement agencies are already using cellular radio systems in addition to their dedicated radio systems for the transmission of voice messages. Almost all urban and suburban areas in the United States are covered by one or more cellular providers, although in sparsely populated areas, coverage

may not be available.

In addition, the construction of personal communications systems (PCS), most of which are cellular systems in the 2GHz band, has proliferated in higher-density areas, and these systems are competing directly with 800MHz cellular communications systems. There are as many as nine different technologies being used by different suppliers of cellular and PCS radio. So, once a user has chosen a company and handsets, it may be stuck with that supplier until the end of the contract.

System coverage

System coverage is a major consideration in selecting a cellular system or PCS. The first thing to do when you think you want cellular or PCS service is to identify the suppliers in your area. Contact them or go to the Internet and obtain a coverage map for your area for each supplier, as well as its prices and terms. Borrow phones from suppliers and test different systems, where available, to determine which one covers your needs best.

Pricing

With the advent of increasing competition in many areas of the United States, the pricing packages are changing rapidly, so you will need to get the latest information at the time of purchase. Law enforcement may have an advantage in negotiating with suppliers because it is a highly visible public agency.

Sample vendors

► **AT&T Wireless Services** — AT&T has cellular and PCS licenses for most of the states in the country. However, it is not licensed in Montana, North Dakota, parts of Minnesota, Wyoming or Texas. To determine if AT&T does provide coverage in your area, it is best to get the actual current coverage maps showing the specific area of interest. (Most can be obtained from the AT&T Web site, www.att.com.)

► **Sprint** — Similarly, Sprint has almost all of the nation licensed for PCS coverage, but it is building its network in the highest-density areas first, where it can most easily attract a large number of subscribers.

Advantages of cellular/PCS Radio

- ❑ Where there is coverage, subscribers should be able to contact any field or fixed personnel, regardless of agency or jurisdiction (i.e., it supports a high

level of interoperability).

- ❑ Pricing is competitive in most areas.
- ❑ Service can supplement dedicated radio communications.
- ❑ With digital protocols used by many cellular/PCS radios, listening by unauthorized scanners is limited or eliminated.
- ❑ Under certain emergency conditions, some vendors can supply portable cell sites to the scene to provide for increased cellular radio traffic.

Disadvantages of cellular/PCS radio

- ❑ Coverage is limited or non-existent in sparsely populated areas.
- ❑ Most systems competing in local areas use different modulation techniques, so a particular hand-held phone may not work with any other system.
- ❑ In some locations, cellular radio systems are prone to overload in emergency situations.

Voice — SMR/ESMR

When the FCC wrote the trunked radio rules, it provided for licensing specialized mobile (trunked) radio service companies (SMRs) to provide leased two-way mobile radio service. As time passed, with the development of digital radio trunking systems called "enhanced specialized mobile radio" (ESMR), greater spectrum efficiency was achieved. These systems use the 800MHz and 900MHz portions of the radio spectrum.

Many SMR/ESMR systems are extremely reliable and are well suited for use by public safety agencies. SMR/ESMR systems work well for radio dispatch and for interconnection to the public telephone system. Offerings are usually competitive with other available mobile radio services.

Sample vendors

► **Nextel** — One ESMR provider with national coverage is Nextel (although, like the cellular/PCS providers, its presence is spotty in small-population areas). Nextel's system uses Motorola's IDEN equipment. The system is quite similar to that of cellular radio; however, in addition to making phone calls, Nextel offers paging and dispatching services whereby a subscriber may call another mobile station or a group of stations on company-owned repeaters. The service allows for full-duplex communications. Thus, one device gives you the capabilities of both a

cellular phone and a hand-held radio.

► **Lower Colorado River Authority** — The Lower Colorado River Authority (LCRA) is a conservation and reclamation district in Texas that monitors and controls portions of the Colorado River. LCRA has an extensive Com-Net Ericsson EDACS digital radio system with extra capacity available for leasing to other utilities and, most recently, to public safety organizations.

SMR/ESMR advantages

- Capital expenses are amortized in monthly invoices and spread over the total customer base of the company.
- Many modes of operation are available by using this service, as discussed above.

SMR/ESMR disadvantages

- The agency must purchase special telephone/radio units.
- Prioritizing transmissions for public safety agencies is generally not provided at this time. In case of an emergency, public safety agencies may not be preferred customers.
- Flat-rate billing may not be provided. Rates are commonly based on a fixed fee plus usage.
- The service may not be available in your area.

Wireless data systems

Regardless of the type of radio system used for data transmission, software also is required for these systems to work properly. Software on the laptop (usually licensed on a per-PC basis) and software back at the main computer site must both be present and be able to talk to each other over whatever backbone you select. The effective speed of your data network will depend heavily on the efficiency of the software used to pass the data back and forth.

Cellular digital packet data (CDPD)

If you are planning on transmitting data for dispatching, for license and criminal record information, or for writing accident reports, CDPD may be the technology to use. CDPD uses packet radio hardware and software and is regularly used with laptop computers or mobile data terminals. CDPD may be available from a cellular supplier in your area. Some CDPD suppliers with

interesting offerings are described in the following section.

Sample vendors

► **AT&T Wireless** — AT&T Wireless Services developed a white paper in 1997 titled "CDPD for Public Safety," outlining the use of CDPD by law enforcement agencies. The document includes information on the wireless environment applicable to public safety dispatch users and the economics for CDPD usage. It compares CDPD with the other options available to public safety organizations for the transmission of wireless mobile data, includ-

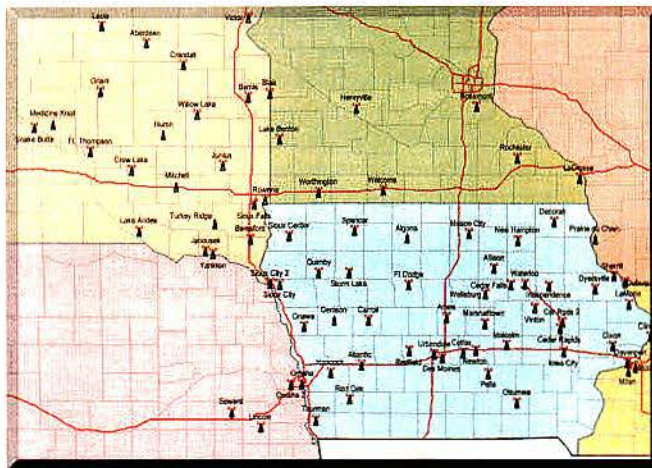


Figure 1. Racom serves 6,000 customers in six states.

ing government-owned, voice- and data-dedicated private mobile radio systems, SMR trunked radio systems, and public networks.

► **Bell Atlantic Mobile** — Bell Atlantic Mobile offers its Airbridge service using CDPD to access the Internet as well as corporate or local government internal computers for database inquiries. The Metropolitan Police Department of Washington uses Airbridge, and patrol car personnel regularly access criminal databases and motor vehicle records using laptop computers.

► **GTE Wireless** — GTE offers an "Intelligent Patrol" turnkey package that bundles together hardware (including a ruggedized laptop computer and modem), software and service, training, installation, integration and maintenance with a leasing option. The laptop computer can handle inquiries to criminal databases, warrants, and mug shots. Besides retrieving information, laptops can also dispatch using CDPD. GTE offers usage-based pricing on its service.

Advantages of CDPD

- The service is available in many areas in the United States and is ideal for applications involving short, rapid data exchange. Police officers can readily access local, state, and national databases from their patrol cars.
- The capital expenses are only for computers, modems and software. The communications network is provided by the cellular service provider, so entry costs for agencies are quite low.
- Information may be obtained quickly from database resources, including NCIC, without the need to extend time to go through a dispatcher.
- The accuracy of the information may be better if it is directly obtained from a law enforcement database without any voice involved.
- Industry standard TCP/IP protocols make the connection with standard databases.
- Some service providers are willing to prioritize traffic on their CDPD networks so that law enforcement may be able to displace non-critical traffic during emergencies.
- Hardware and software are available from multiple sources, allowing for competitive bids in a community where there is more than one source.

CDPD can act as a backup communications network if the primary law enforcement radio communications network goes down.

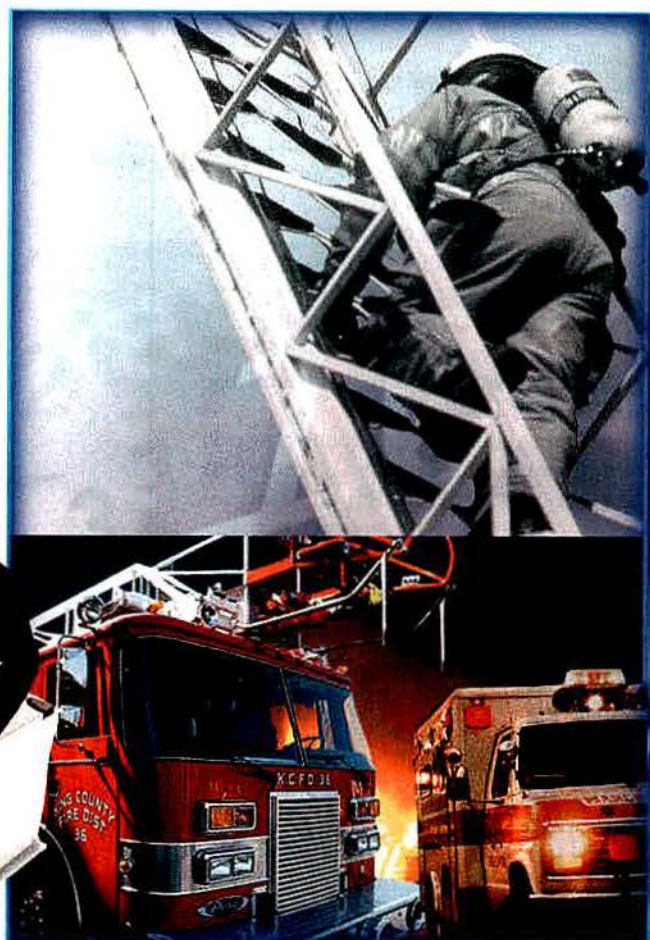
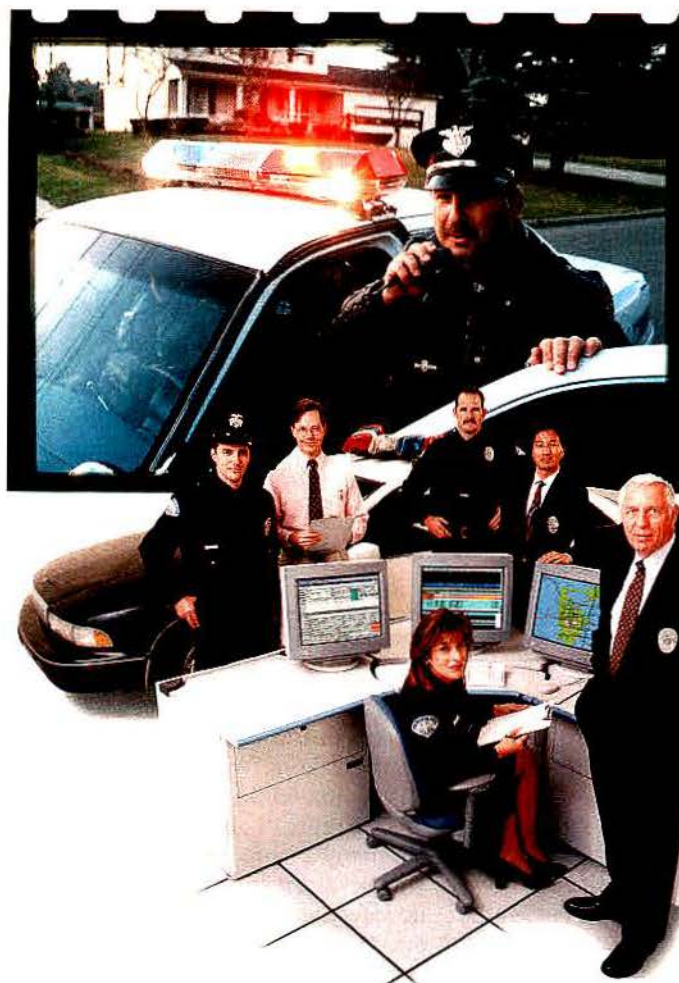
Disadvantages of CDPD

- CDPD cell coverage may be limited or not available in sparsely populated communities or rural areas.
- There may not be enough capacity to handle law enforcement requirements during a heavy rush for information.
- The maximum data rate is 19,200bps, which may not be satisfactory for obtaining high-quality fingerprints or complex mug shots quickly.
- In large agencies with a large number of vehicles, the cumulative cost of CDPD service could exceed the cost of a dedicated radio infrastructure.
- Some service providers will not prioritize traffic for public safety users.

Private national data networks

At this time, there are two private national data networks: ARDIS and RAM.

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Both networks offer data communications services within urban areas and between many cities across the continental United States, Alaska, and Hawaii.

Sample vendors

► **American Mobile Satellite Corporation (ARDIS Mobile Data)** — Motorola recently sold its ARDIS data and messaging network to American Mobile Satellite Corporation (AMSC), making AMSC the owner of the largest two-way wireless data communications network in the United States. The network covers 427 urban areas (10,700 cities and towns) in the continental United States, Alaska, Hawaii, Puerto Rico and the U.S. Virgin Islands.

Packet data network technology is employed by the system. According to the company, the combined satellite/terrestrial network allows the company to optimize the transmission of data by using both terrestrial and satellite paths, thus minimizing their costs.

► **BellSouth Mobile Data (RAM Network)** — BellSouth Mobile Data Corporation took over RAM Mobile Data in early 1998 and is expanding the number of base stations in metropolitan areas across the United States. According to BellSouth, "The primary objective of the RAM network is to send and receive messages and data from anywhere at anytime." The system is a data-only, packet-switched network and uses packets of 512 bytes transmitted at an 8kbps rate. The service is based on Ericsson's Mobitex standard used throughout Europe. The network supports many data communications protocols including UDP/IP, TCP/IP, SNA/3270, X.25, asynchronous, and MPT/I transport protocol.

To operate on the RAM network, an agency needs laptop or palmtop computers, application software supported by appropriate middleware, a wireless modem and BellSouth's RAM wireless two-way data transmission service. BellSouth provides open interfaces that enable many vendors to supply hardware, software and system integration services. Coverage information may be obtained from the company's Web site. As said previously, an agency is encouraged to perform its own coverage testing before making a commitment for the use of the network.

Information on the system may be obtained by calling BellSouth or by visiting its Web site.

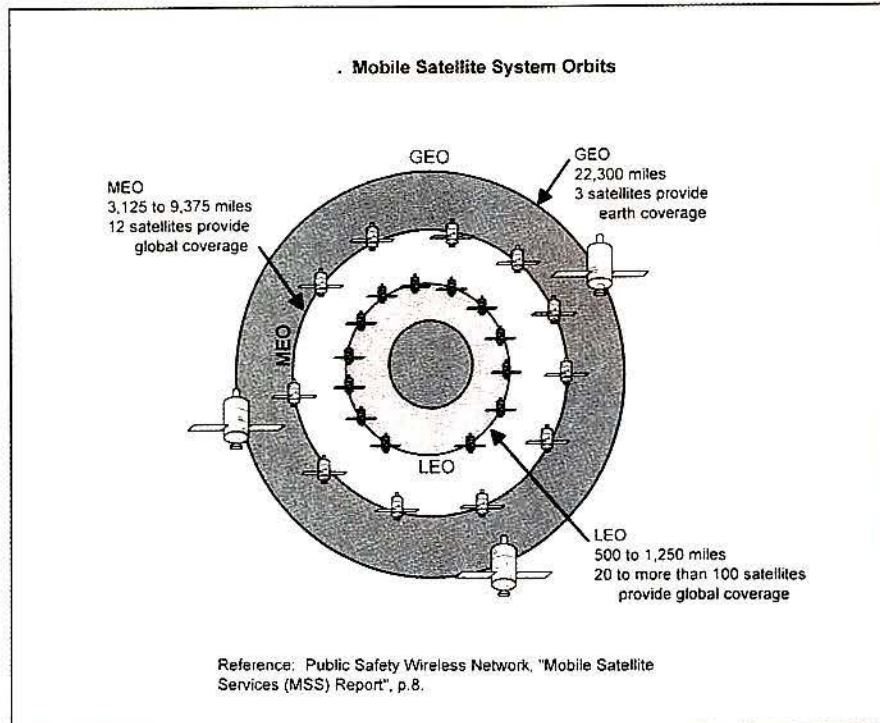


Figure 2. Voice communications satellites relationships.

Advantages of private data networks

- ❑ Network store and forward. Packets may be stored for sending at a later time.
- ❑ Companies guarantee fast network response and delivery of data, within seconds of being transmitted.
- ❑ Both companies provide encrypted service, if desired.
- ❑ Costs are proportional to usage.

Disadvantages of private data networks

- ❑ The two national data networks do not yet support data rates in excess of 8kbps.
- ❑ Because these are packet networks, with 200 to 1,000 bits per packet, they are not very efficient for long messages. They need to be used for files of less than 10,000 bits.

Regional voice and data systems

A number of ESMRs provide digital radio systems for both voice and data traffic. One is discussed below. Other communications and utility companies across the country have offerings for the provision of regional communications.

Sample vendor

► **Racom Corporation** — This company, headquartered in Marshalltown, IA (See "It Is Heaven—and It Is Iowa," *MRT*, May 2000), operates a large 800MHz trunked digital wireless

network and boasts of some 6,000 customers in Iowa, Minnesota, Nebraska, South Dakota, Wisconsin and Illinois with some 4,000 contiguous channels (see Figure 1 on page PS4). The company's core business consists of wireless voice and data services for public safety, utility, and industrial customers. By combining the needs of many entities on a common network and providing a high level of network maintenance, Racom claims that users can avoid substantial cash outlays while experiencing a high degree of system reliability and flexibility.

Advantages of regional voice and data

- ❑ Lower capital outlay by sharing existing system.
- ❑ Maintenance is taken care of by the system supplier.
- ❑ Capital expenses are amortized in monthly invoices and spread over the total customer base of the company.
- ❑ Many modes of operation are available by using this service, as discussed previously.

Disadvantages of regional voice and data

- ❑ Law enforcement agency does not have complete control over the system.
- ❑ The agency must purchase special telephone/radio units.
- ❑ Prioritizing transmissions for public safety is often not provided. In case

- of an emergency, public safety agencies may not be preferred customers.
- ❑ Flat rate billing may not be provided by companies. Rates are commonly based upon a fixed fee plus usage.
- ❑ The service may not be available in your area.

Mobile satellites

► *Voice communications satellites* — Besides GEOs, medium-earth-orbit (MEO) and low-earth-orbit (LEO) satellites have been proposed for relaying radio transmissions. MEO and LEO satellites require less output power from phones and have less time delay than GEO systems. The relationship of GEO, MEO and LEO satellites is shown in Figure 2 on page PS6.

► *Other voice satellite systems* — Four other PCS satellite systems are being installed. Two similar systems, Globalstar (being implemented by Loral and Qualcomm) and Constellation Communications's ECCO, are LEO systems with 48 and 46 satellites, respectively. As of February 2000, it appears that these companies are proceeding with their plans even though another provider, Iridium, has filed for bankruptcy.

Mobile Communications Holdings' Ellipso and ICO Global Communications' ICO satellites are in MEOs, spaced at about 6,000 to 10,000 miles above the earth's surface.

There are tradeoffs between the LEOs and MEOs. Far fewer satellites are required in the MEO system than in the LEO system, but higher effective power is required for transmissions by the subscriber units, and time delays are greater.

Pricing of services has not yet been finalized, but it is estimated that prices will be in the range of \$3 to \$5 per minute. Almost all of these companies have Web sites. Visit those sites as the technologies develop to evaluate the use of satellite services as they become operational. Because of the large number of commercial providers for both voice and data systems, there will most likely be considerable competition when all of the systems are turned up.

► *Data communications satellites* — Since 1992, American Mobile Satellite has offered Skycell service employing geosynchronous satellites for communication of data up to 4,800bps. Both voice and data may be handled on the same system.

One type of use of the Skycell system

includes mobile messaging services for large fleets that can be used virtually anywhere in North America. The system uses L-band technology with antennas mounted in small domes on the roofs of vehicles to allow for two-way data transmission and position tracking. Interfaces use standard dispatch application software. The service may be used to send data reports, email, and faxes, as well as to connect to the Internet.

► *High-altitude long-endurance (HALE) platforms* — In this proposed network, relay of signals would be accomplished using large blimp-like repeaters at several miles (20,000m) above the earth. The devices would cost less than the big satellite systems and could be recalled to earth for maintenance. Multibeam, phased-array antennas would support both mobile two-way communications and broadband video.

Four types of HALE platforms have been proposed, which include:

- ❑ helium-filled, robotically controlled dirigibles stabilized by ion engines.
- ❑ units powered by solar or fuel cells.

- ❑ piston-driven platforms.
- ❑ jet engine-driven platforms.

The biggest challenge faced by all of them will be power requirements versus refueling requirements. The first two types need little or no refueling but may not produce the transmit power needed, whereas the latter two types will have plenty of power but will need to be refueled every few days.

* * *

Summary

At no time in the history of public safety communications have so many options been available. Technological advances and regulatory changes have combined to make selecting a communications system very complex.

As we move into the future, it is unlikely to get any better. NLETC-Rocky Mountain and other groups [such as the Federal Public Safety Wireless Network program (PSWN)] are dedicated to helping you through the maze of technology jargon and bureaucratic rules as you proceed on your communications project. ■



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Aether Systems acquires Cerulean

Aether Systems, Owings Mills, MD, signed a letter of intent in August to acquire Cerulean Technology, Marlborough, MA.

The acquisition allows Aether, a provider of wireless data products and services, to enter new vertical markets in the public sector by delivering products to the mobile government marketplace. According to the U.S. Bureau of Labor Statistics, the market for mobile data products across the government will represent an estimated 3.7 million users and more than \$1 billion in products and services by 2003.

The letter of intent provides for a purchase price of \$150 million, with as much as 50% payable in Aether stock.

"Aether looks for three valuable resources in its merger and acquisition strategy: entry into new vertical markets, a recurring revenue model and engineering bandwidth. The acquisition of

Cerulean brings us all three of these crucial elements," said Dave Oros, chairman of Aether Systems.

More than 45,000 users at 700 public safety agencies use Cerulean's Packetcluster family of mobile applications, according to a Cerulean press release. Cerulean now plans to offer handheld products and Web-based services.

"As the public safety mobile market evolves beyond in-vehicle laptops to hand-held devices, more customers are looking for packaged systems that incorporate the application software, devices, air time and ongoing support in a turnkey solution for a monthly fee," said Bob Badavas, chief executive officer of Cerulean.

"As part of Aether, Cerulean will be able to more easily meet this demand by offering hosted data services, managed through Aether's network operations center," Badavas said.

OSHA fines Portland for radio failures

The Oregon Occupational Safety and Health Division has fined the city of Portland \$3,600 for failures in its emergency radio dispatch system, according to a story published in the *Oregonian* and written by Maxine Bernstein.

The story reports that inspectors found violations in which Portland police officers had been unable to call for cover on their portable radios, unable to communicate with fellow officers responding to a call or unable to contact a dispatcher when stopping a suspect.

A complaint from Portland police Sgt. Lonn Sweeney prompted state inspections in April and June. Sweeney had sent numerous memos detailing the problems to the Portland Police Bureau and its chiefs during the past five years. He said he filed the complaint because he never got a response.

More than 80 agencies in the metro area use Portland's \$8.5 million, 800MHz radio system, manufactured by Motorola and operating since 1994.

OR-OSHA, in its citation, identified three shortcomings that the city had not addressed. The first shortcoming was in not making the orange emergency button on officers' hand-helds operational. The radio

system is supposed to allow an officer to press the button in case of emergency, but it never has been programmed. The button would override any other voice traffic.

The city argued that a policy decision had been made not to use the emergency buttons because they might be activated accidentally, lock other channels from use or interfere with dispatch.

The second shortcoming cited was not ensuring that officers have adequate radio communications capability in all areas of Portland. OR-OSHA found that officers hit coverage nulls in certain parts of the city, preventing them from calling for cover or contacting other officers in their districts because of inadequate radio signal strength.

The third shortcoming identified was failing to expand the system sufficiently to keep it from becoming overloaded as new users were added to it. When the system was installed, only a handful of Portland bureaus used it. In the past six years, the number of radio users has snowballed to include seven Portland bureaus and 80 outside agencies.

The city contends the system can handle the expansion of users and plans to challenge the citation.

Kentucky patrol completes digital system pilot

The Kentucky State Police (KSP) has completed the installation and testing of its pilot radio communications system, paving the way for system installation statewide. The digital communications systems will serve the agency's 16 command posts, and the KSP projects the new digital communications system will be installed statewide by late 2001.

Originally contracted with Motorola in December, the \$22.8 million Astro 25 digital conventional two-way system will replace the agency's UHF analog conventional system purchased in the 1970s.

The KSP and Motorola selected the agency's Richmond Command Post as the site for the pilot system because of the mixture of mountains and flatlands in the area the post serves. The Richmond Command Post covers 22 counties in central Kentucky.

"We are proud of the work performed by the state police, Motorola and so many others on the pilot system to ensure that we will have the communications capability necessary statewide to respond to increasing public safety needs of Kentucky citizens," said Capt. Kenneth Hardin, KSP communications commander.

The KSP's communications system will allow transmission on two new digital channels and one existing analog channel at each of more than 90 sites. It will also use multicast technology to provide improved wide-area coverage. With multicast technology, the signal is broadcast from a number of transmitters, with each transmitter on a different frequency. A software program, Conventional Voice Scan, enables the system's mobile and portable radios to automatically select the site with the strongest signal and transmit back on a common frequency. The new system will also operate on 12.5kHz radio channels.

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Headset project for fire suppression tractors



Photo 1. Crawler tractors such as the one shown here are used to fight wildfires in South Carolina. Photo courtesy of South Carolina Forestry Commission.



Photo 2. This fire-suppression crawler tractor is equipped with a blade and a fire plow.

By Harold Kinley

It is a firefighter's job to protect the public's lives and property from wildfires. The firefighter is asked to put his own safety on the line—there is no such thing as making a firefighter's job safe. However, the South Carolina Forestry Commission,

including the communications department (of which I am part), takes every affordable step to improve the safety of our firefighters. Although such steps may not make the job completely *safe*, it could be said that the safety improvements make the job *less dangerous*. The basic equipment used in forest-fire suppression in South Carolina is the *crawler tractor*:

Some of the tractors have a blade, some have a fire plow and others have both. (See Photos 1 and 2 at the left.) The focus of this column is on the headset situation used by firefighters operating crawler tractors.

In state government, it is a sad fact of life that sometimes budget constraints are a limiting factor on what can be purchased for our communications needs, even when safety might be adversely affected. We would love to have everything *plug and play* right out of the box. However, plug and play often gives way to *hope and pray* that we get something. In short, we learn to make do with less and improvise where possible and when necessary. It is often said that "necessity is the mother of invention." This is never more true than in public safety communications.

The request

At a staff meeting, a forestry supervisor asked me to find out the cost and all the particulars about supplying headsets with boom microphones for his firefighters. A few years before that I had already experimented with a headset and an interface to connect it to the Maxtrac 300 radios that are installed in our fire-suppression crawler tractors. (See Photo 3 on page 20.) Other job requirements forced this project onto the "back burner." So when the forestry supervisor came to me with this request, I was already well on the way to building a crude prototype that could be offered for trial and demonstration purposes.

The beginning

Figure 1 on page 20 shows how the idea was implemented. Here, the interface to the radio consisted of a small preamplifier kit that was designed around the LM386 integrated circuit. The output of the preamplifier was fed through an audio impedance-matching

Contributing Editor Kinley, *MRT's* technical consultant and a certified electronics technician, is regional communications manager, South Carolina Forestry Commission, Spartanburg, SC. He is the author of *Standard Radio Communications Manual, with Instrumentation and Testing Techniques*, which is available for direct purchase. Write to 204 Tanglewyld Drive, Spartanburg, SC 29301.

Kinley's email address is hkinley@home.com.

The Motorola R2625: Designed to work on ASTRO® turf.



If you work with ASTRO® 25 diagnostic testing, the Motorola R2625 may be just the analyzer you've been waiting for.

The R2625 is specifically configured for ASTRO 25 (APCO Project 25) diagnostic testing, as well as for ASTRO 25 with conventional two-way analog systems. The R2625 takes all the features you like about our R2600 model and combines them into a special digital hardware platform that's especially ASTRO- friendly.

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The R2625's specialized, dedicated, easy-to-access test screens are conveniently grouped together to expedite test set-up. The R2625 accepts both customer and key test codes for encryption testing, and delivers an impressive

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- Dedicated screen displays for convenient observation or printout of test results
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MOTOROLA



Photo 3. Maxtrac radios are mounted in a special radio box that is mounted under the top of the canopy of the tractor.

transformer (RadioShack part # 273-1380). This transformer has an 8Ω primary and a $1,000\Omega$ center-tapped secondary winding. The center tap of the secondary was used to match 8Ω to 500Ω . In kit form, the preamplifier cost was \$4.06 from Marlin P. Jones Associates.

Photo 4 on page 22 shows the preamplifier and transformer mounted inside the Maxtrac control head. The small internal loudspeaker was removed to make room for the preamplifier and transformer. The transformer was secured with silicone rubber. Removal of the small internal speaker gave plenty of

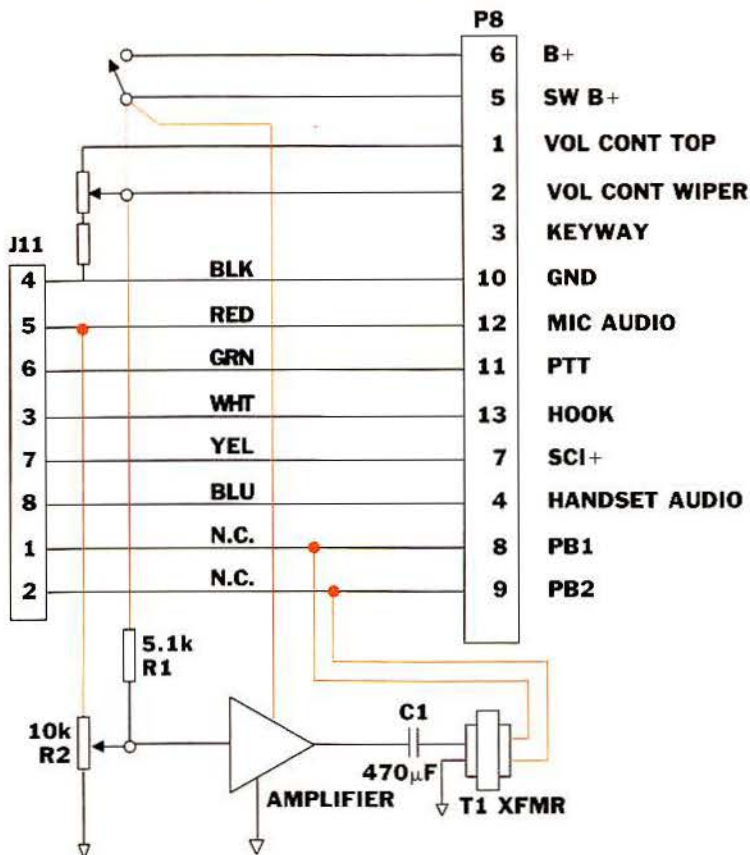


Figure 1. The mixer/preamplifier is placed inside the Maxtrac control head and wired directly in as shown by the colored wiring.



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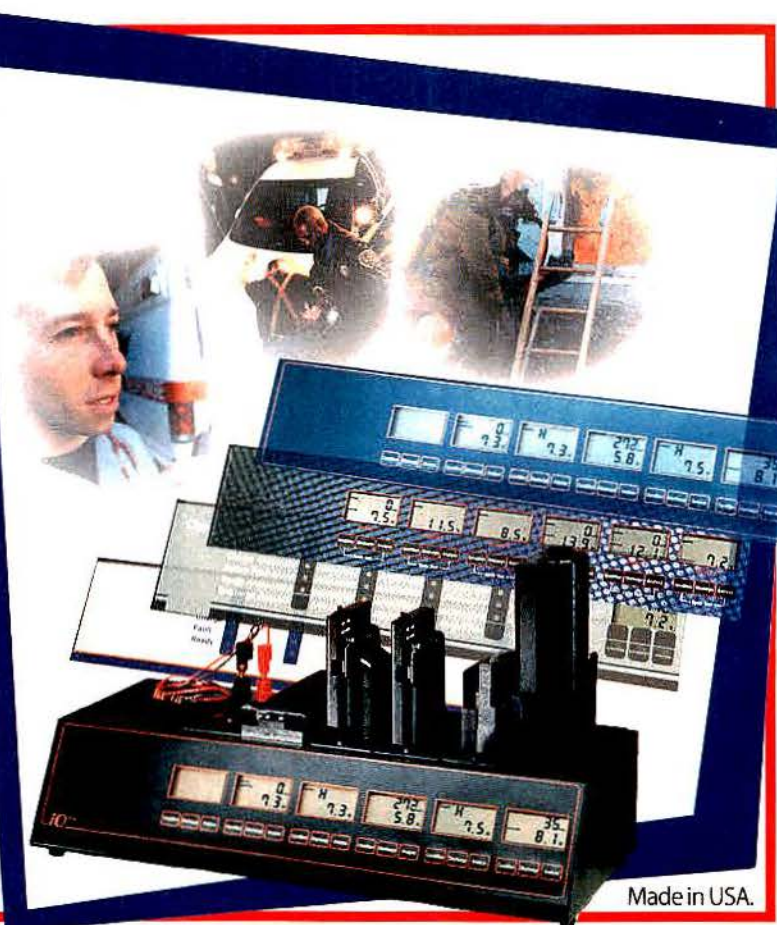
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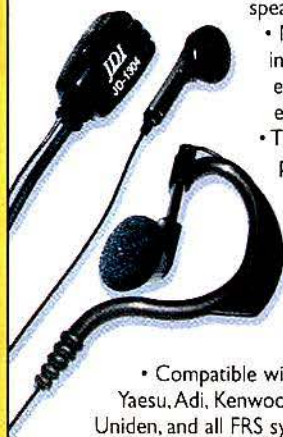
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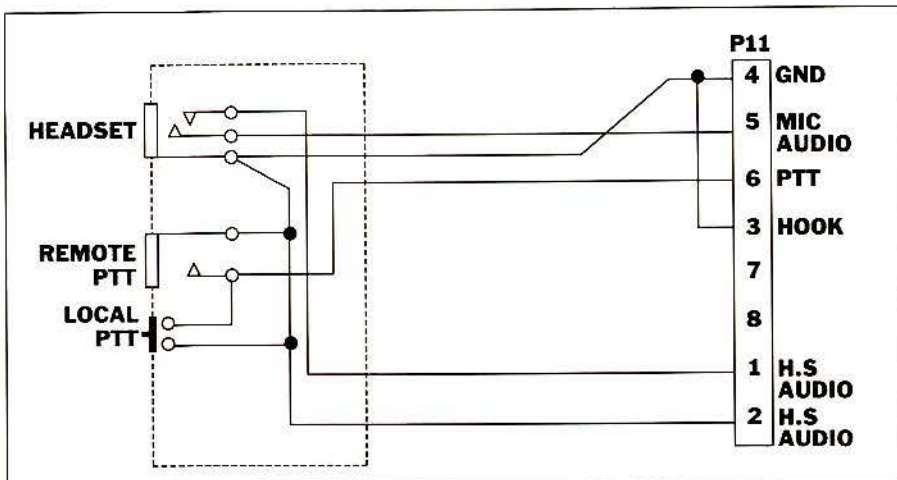


Figure 2. This interface box provides for connection to a headset such as the David Clark model H-3440. Provision is also made for connecting a remote PTT box, such as is shown in Photos 7 and 8. A local PTT button is also provided on the interface box.

room to mount the preamplifier and transformer. The internal connections are shown by the colored lines on the schematic in Figure 1 on page 20. As shown in Figure 1, the microphone audio is fed through potentiometer R2 to the audio preamplifier input. A second input to the preamplifier, through resistor R1, feeds the receiver audio from the wiper of the volume control to the preamplifier input. The microphone audio is fed through the preamplifier to provide *sidetone* to the operator. The sidetone is continuous, whether the operator is transmitting or not. This helps bring in ambient sounds to the operator so that he isn't impaired from hearing outside sounds, although it is at a much reduced level. In the transmit mode, the sidetone allows the operator to hear himself so that better control of the voice is achieved. It is hard to appreciate this unless you have ever tried to talk without being able to hear your own voice.

The diagram in Figure 2 above shows the wiring inside the interface box that provides connectivity for the headset, local PTT and remote PTT buttons. Photo 5 on page 24 shows the interface box mounted to the side of the radio box that houses the Maxtrac radio. P11 is the eight-pin RJ-45 plug that plugs into the Maxtrac microphone jack, J11. The microphone setup here was designed for a David Clark model H-3440 noise-canceling electret microphone. Bias is supplied from the radio to operate the electret microphone. The remote

PTT jack allows a small, remotely located PTT switch to be used to key the transmitter. Photos 6 and 7 on page 24 show the remote-control PTT box. If the remote control PTT box is not desired or not needed, the local PTT button mounted on the interface box can be used to key the transmitter.

Too many requests

Initially, the request was to supply the headset capability for about 10 of our fire suppression tractors. We could perform the necessary radio control head modifications and the installations for

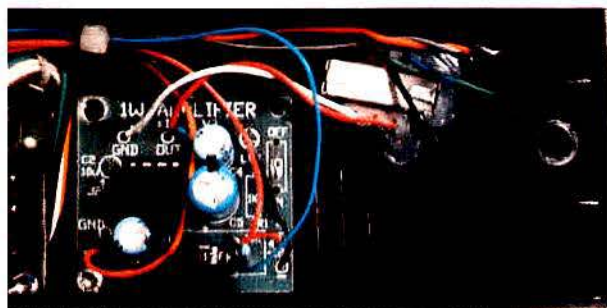


Photo 4. As shown here, the preamplifier and the impedance-matching transformer are mounted inside the Maxtrac control head where the internal speaker was removed. The transformer is secured in place with silicone rubber.

this many units within a reasonably short period of time. However, as word got around, and the prototype was demonstrated, the request list grew to a level that was beyond our ability to satisfy by doing all the work ourselves.

Why not use off-the-shelf equipment that was already available from some companies that are in the headset business? Two reasons: cost and design. Interface boxes are available from some companies to connect their headsets to many different radio models. However,



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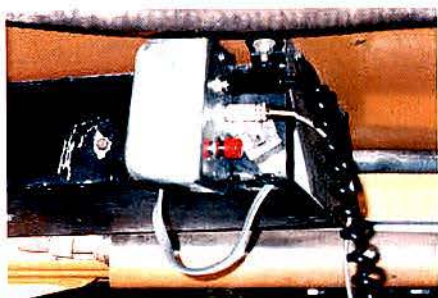


Photo 5. The interface box shown here is attached to the side of the radio box. A short jumper cable connects the interface box to the microphone input jack on the Maxtrac.

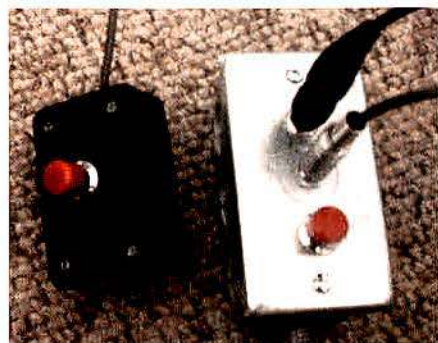


Photo 6. The remote PTT box (black box) shown here is connected to the interface box through a quarter-inch audio plug and jack.

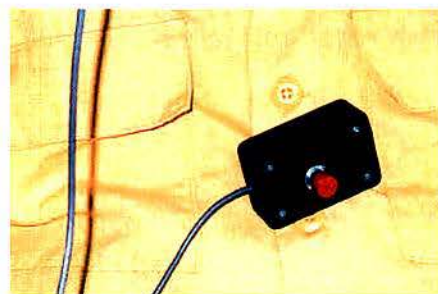


Photo 7. Here, the remote PTT box is attached to the shirt of the firefighter for easy access.

the interface box was between the headset and the radio microphone jack and had to be worn on the belt or some other such location. In addition, the headset along with the proper interface box was costly. So, what next?

The search for plug and play

Now it was back to the search for the perfect headset for our needs at a price that we could afford. About this time I became aware of a company called Peltor. A call to its toll-free number put me in touch with a man who seemed interested in our project and willing to custom-design a headset just for our needs—and at a price that even we might afford. Shortly thereafter, the prototype headset was delivered and the trial pe-

riod began. See Photo 8 at the right.

The headset did not need an interface box to connect directly to the Maxtrac microphone jack. All of the electronics are contained in one of the ear cups. First, the headset didn't have enough volume with the tractor running, and the radio wouldn't scan with the headset connected. Referring back to Figure 2, you will note that the hook switch point is grounded. This allows the radio to scan. If a call is received on one of the scanned channels, there is enough delay to allow the operator to key the transmitter and to talk back to the calling party.

The scan problem was a quick and easy fix. Simply connect the proper wire to ground. The other fix was a little harder to achieve. After trying out the headset, I called the engineering department at Peltor and advised them of the problem. They were a little puzzled at the lack of sufficient volume from the headset but offered several suggestions to increase the volume level. All were implemented with only marginal improvement in the volume level. When a tractor wasn't available for testing, I plugged the headset into the Maxtrac in my service van. Wow! The volume level was overwhelming from this radio.

So, what's the difference? A call back to the Peltor engineering department with this information soon led to the discovery. The radio in my van was a different-model Maxtrac from the one in the tractors. It was discovered that the audio feedpoint for the headset (labeled "hand-set audio" in Figure 1) had a 10k resistor in the line on the tractor radios, and this was killing the audio level at the input to the headset preamplifier. The resistor in the other Maxtrac model was a 560Ω resistor—quite a difference. With this information, Peltor changed the design a bit and sent another headset for us to try. This headset proved to have sufficient receiver audio.

The field trial

The next stage of the process involved placing the headsets with various firefighters stationed around our region for on-the-job testing. The response from the field was overwhelmingly positive. The question became "When do I get one?" The headset was made to order and worked exactly as needed and expected. The price was fair—but not free.

The only thing more impressive than the headset was the willingness of the people at the Peltor company to work

with us and find the best design to fill our particular needs—all this with no guarantee of a major purchase. In this age, when many company representatives won't even bother to return your phone call, it is refreshing to find a company with employees who seem dedicated to the idea of customer service.

Did we buy the headset? Well, not yet—the old budget thing still gets in the way. However, the Peltor headset has been placed on the high-priority list by the firefighters in our region. Having used the headset for awhile, most of them have come to realize just how badly they need them. The headsets provide a good measure of hearing protection from the loud noise of the tractor and allow the firefighter to easily hear and understand radio transmissions.

For a comparison between the regular hand or palm microphone and the noise-canceling Peltor headset microphone, check the electronic version of this article on the *MRT* Web site (www.mrtmag.com) in October. We created special sound files for this article. The WAV files demonstrate the difference that the noise-canceling microphone makes with the crawler tractor running. And, while you are on the Internet, stop by the South Carolina Forestry Commission's Web page at www.state.sc.us/forest/index.htm.

Until next time—*stay tuned!* ■



Photo 8. The Peltor headset can be worn underneath a hardhat. The red PTT button located on the earphone cup allows easy access by the firefighter. The volume control is located near the bottom of the earphone cup. All of the electronics for the headset are located inside the earphone cup.

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Get your 'mobile' runnin'

The communications infrastructure for coordinating the assembly of America's most notorious motorcycle was 'born to be wireless.'

By Matthew Halverson

The small, to-the-point sign that stands guard over the brooding, steel beasts in the employee parking lot at Harley-Davidson's newest regional plant in Kansas City, MO, implies not so much a *request* as a *threat*:

Employee motorcycles—Do not touch or sit on.

Respect for others' property and common courtesy are the virtues that usually encourage us to obey such signs. In this case, however, it's the fear of receiving a violent throttling at the hands of a snarling pack of bearded cyclists that causes me to give the

bikes a wide berth as I approach the plant. These motorcycles are neither possessions nor toys to their owners. Instead they are gas-powered prosthetics. It's no surprise, then, that the same men and women who build these rumbling steeds take the utmost care in constructing each "hog" by hand. One integral component of this process is communications.

The rise of the Hell's Angels biker gang (and the subsequent legends they spawned) in the '60s and '70s applied an infamous stereotype to anyone associated with Harleys. So, based on the outdated reputation of this not-so-motley

'Gonzo' Halverson is associate editor.

crew, an uneducated observer might guess that the employees on the line at Harley-Davidson communicate by an archaic language of grunts and chest thumps. A tour inside the doors of the three-year-old facility, however, gives an insight into the modern but sometimes-troubled portable radio communications system that nonetheless helps to keep the beautiful, powerful machines flawlessly rolling off the line.

It became apparent that the topic of communications problems might arise at some point in the day after I waited 15 minutes at the security station for my ambassador to Harley, Phil Swope. Swope is the head of security and was my impromptu tour guide for the day. As Darryl, the security guard manning the station, tried repeatedly to raise Swope on channel 5 of the 15-channel system with no success, he shrugged his shoulders in confusion and offered "He'll be here in a minute" more than once. When he did arrive, Swope apologized with a self-effacing laugh and explained the delay. His radio had been tuned to the wrong channel.

Communications at the Kansas City arm of Harley-Davidson is not so much vital as it is the grease in the plant's operations. According to Terry Harrison, a maintenance electrician who helped set up the UHF system contract with vendor TFM Communications (Topeka, KS), about 125 of the 450+ employees carry 4W, Motorola Visar radios for reasons ranging from maintenance support to production-line supervision.

"It's a general-purpose communications system," Harrison said. "Plus, if there is downed equipment, it's used for that."

Certain departments have dedicated channels on the system, such as materials and security/safety. Others, such as paint and assembly, have several channels from which to choose. Maintenance, the watchdog for the entire plant, is plugged into the entire system.

In a plant encompassing 330,000 square feet, legwork is half the battle in solving maintenance problems. Maintenance personnel can not be everywhere at once, and trekking from one end of the facility to the other for a maintenance call can be a time-consuming process. Ted Harris, president of Pace Union, Local 670, said the radios are the most important tool at the disposal of the maintenance team.

"They just save a lot of legwork," he said. "The availability to get an immediate response with the radio on is well worth the money that you're spending on them."

Harris said many maintenance calls can be handled over the air. Those employees that do have radios have them because they are familiar with the area and the equipment, so they are able to give an accurate, detailed account of what is wrong. Therefore several small problems are solved with a little "back-and-forth."

Maintenance employees don't spend all of their

'Ponch' never had it this good

Motorcycles, especially Harleys, are traditionally associated with rebels, outlaws and tough guys—the people who live on the other side of the law. How ironic, then, that Harley-Davidson is the largest supplier of police motorcycles in the world. Boasting an 80% market share, Harley-Davidson Police Motorcycles sells bikes to more than 2,000 law enforcement agencies in North America and agencies in 44 countries.

Motorcycle duty may be a one-man job, but just because mounted officers ride alone, that doesn't mean they don't need to stay in contact with other officers. In fact, riding solo makes communications that much more important.

In the arena of public-safety communications, one company stands out from the rest, according to Jon Syverson, Harley's manager of worldwide Police and Fleet sales.

"From our standpoint, I would say that probably 70% to 80% of the business is still focused on one manufacturer, and that is Motorola," Syverson said. They have the lion's share of the business of mobile radios, and they certainly are the most aggressive."

Throughout the design and construction of Harley-Davidson's FXDP Dyna Defender model for 2001, the company took every step necessary to make the bike compatible with today's public-safety radio systems, he said.

"Our engineers have worked very closely with Motorola engineers as we developed the new model," he said. "We worked very much 'hand-in-glove' with Motorola in the design and launch of our new models."

Harley police motorcycles are not built specifically for Motorola radios, however. The bikes are built with police wiring harnesses that support a "plug-and-play" architecture. Those departments wishing to build their own systems can take training courses from Harley technicians on how to equip the bikes.

Just the facts...

- ❑ **Harley-Davidson has been making police motorcycles since 1908—just five years after the company began producing bikes.**
- ❑ **Harley police bikes are built in the York, PA, facility.**
- ❑ **The company offers three police motorcycle models:**
FXDP Dyna Defender
FLHPI Road King
FLHTPI Electra Glide
- ❑ **The largest police customer Harley-Davidson has is Mexico City, which has more than 700 bikes in service.**



Photos courtesy of Harley-Davidson Police sales

time on the radio troubleshooting from a distance, however. When they need to take a more hands-on approach to the job, Harris said they expect the radios to handle the bumps and bruises that are part-and-parcel of physical labor.

"Maintenance is an environment where things have to be pretty heavy-duty," he said. "Now, if you're in dress pants or slacks, and you're just moving around a little bit, then that's OK. But when you're going from the floor up to the rafters and crawling all around, you're really getting

into the harsher environments. You want that radio to hold up."

Harris is happy with the durability of the Visars. For him, the most important requirement of the radios, however, is intrinsic safety. With an entire department of the plant devoted to painting the bikes' gas tanks, non-intrinsically safe radios could spark paint fumes and blow the building like a Roman candle—and fried beard hair is not a pleasant smell.

"There are a lot of fumes in [the paint department], and people can walk in and

out with their radios, so we have to make sure that they're all intrinsically safe," Harris said. "That's probably the biggest thing we're worried about."

Though not Motorola's most expensive radio, the compact, rugged radios are ideal for Harris' and Harley's needs.

"The main thing is, it cuts down on lead and lag time. You just have to have people disciplined enough to wear them," Harris said.

As my first encounter with Swope demonstrated, however, just getting employees to wear the radios is not enough. Having them on the right channel in a conventional environment is equally important. Lapses, such as Swope's channel mix-up, however, will happen.

"We all do it," Swope explained. "It's not the ideal situation, but it happens. You get busy, you talk to someone on channel 4, and then you don't move it back up to channel 5. That happens."

A ride around the production floor on Swope's golf cart reveals an immaculate plant where the only disharmony comes from the thundering machinery. Making oneself heard over the surplus ambient noise is a job in itself. In the absence of radios, two employees would be forced to yell in each other's ear at close range to be heard. The safety goggles required to be worn while on the floor are as necessary for protecting the eyes from the errant spittle of a close-talking coworker as from flying shrapnel.

In the considerably less-noisy cafeteria, Swope shrugged his shoulders and turned his eyes to the ceiling while discussing the havoc the industrial clamor wreaks on plant communications. Everything from the engines of the numerous forklifts to the spotwelders on the assembly line contribute to the racket. What exacerbates the communications problem, however, is what Swope calls "the human element."

"It's the guy that's riding the forklift and has his radio sitting somewhere beside him, possibly turned down too low to hear" that impedes communications, Swope said. There is no written policy or procedure for plant communications, but he encourages employees to be smart while carrying radios.

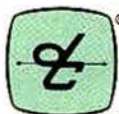
Amplifying the noise problem and human element further is the employee use of personal stereos with earphones. Assembly line workers are allowed to listen to Walkman-style radios (although headset use is restricted to only

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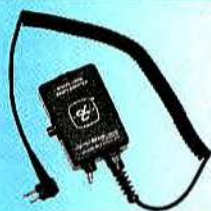
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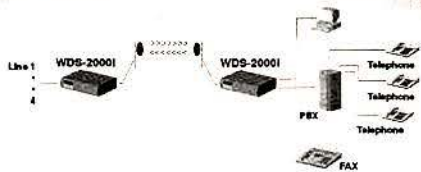
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one earphone), but Swope pointed out that deciphering the difference between Metallica in one ear and radio transmissions in the other can cause lapses in communications. An attempt at switching to full headsets for plant radio only caused more problems.

"We tried to use two-ear headsets, but when [the employees] saw someone with a full headset, they complained about it—'Well, I can't have it for my CD, how come he can have it for his company radio?'"

The answer to such a question seems painfully obvious, but Swope only rolls his eyes and chuckles when asked how he responds to such complaints.

Not only have headsets caused squabbles over personal privileges, they've been the subject of employee mockery. Harris said one employee who tried to use a full headset turned more than a few heads during his short-lived communications experiment.

"We had a guy that walked around here for awhile with a headset that looked like a CIA double agent," Harris laughed. "People kind of made fun of him, and it didn't last very long."

As a compromise to the headset problem, lapel microphones were issued to all of the radio users. Harris said they are powerful enough to overcome the ambient noise, but their use is not mandatory.

The communications system has had its share of growing pains as well, and it appears to be approaching its limits. The system's initial configuration suited the facility well at first, but as bike production increased, it began to show signs of weakness. As more interior walls were constructed and as more machinery flooded the plant, Harris said the

original radios were almost useless.

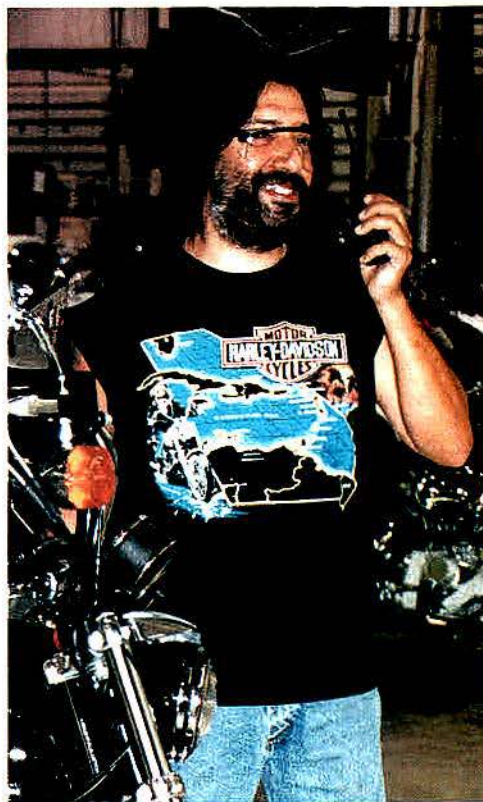
"It got to the point where it was almost impossible to hear unless you were out in the open and looking at each other," he said.

To ameliorate the problem, two 25W repeaters were installed for the maintenance and materials departments. Harrison said the system is working fine now, but he thought better initial planning could have saved

headaches down the line.

"I like the system itself, but it would have been nice if we could have foreseen the future and gotten a couple more channels," Harrison said. "Everybody's covered, but it just would have been nice to have about five more channels."

Human error and size constraints aside, the radio system serves the plant well. At present, the plant's workers build more than 180 Sportsters per day, and each bike that rolls off the line

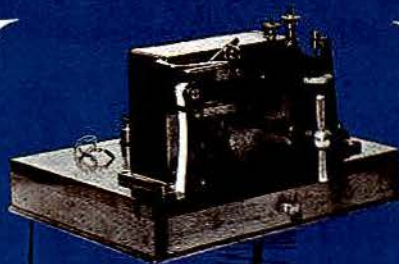


Harley-Davidson assemblers coordinate activity with Visar portables.

has already been sold. Yet at that rate, the plant is still 214 bikes behind for the quarter. Swope didn't bat an eye when quoting the number. He said the difference can be made up in one Saturday and a couple hours of overtime.

On my way out of the building, the employee bikes catch my eye yet again. They're beckoning me and promising fast rides on dusty back roads. I've become privy to the fact that Harley communications can be suspect at times. Maybe their security isn't very tight either. My finger slides across the black gas tank of an XL 1200C Sportster, and I can feel the beast's steel heart lightly thumping from within.

My impulsive act of indiscretion has left me with only one option: As I look over my shoulder, I jog the rest of the way to my car. ■



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Reduce noise in distributed communications systems

Back-end design fixes cannot improve a bad "noise launch" at the radio system input, but tower-mounted amplifiers can improve overall system noise figure.

By Bob Swinney

There are many types of *noise*. Most are nuisances, and some are downright destructive to communications. Two types of noise can affect the operation of all *active devices*, including transistors, packaged amplifiers and radio receivers. One type of noise is generated *within* active devices, effectively limiting the number of components or amplifiers that can be chained. The other is *desensitizing noise* that literally overloads, or swamps, the input stages of amplifiers and receivers, rendering them insensitive to intended signals.

Internally generated noise (equipment noise) is *additive* with other system noise.

Noise-threshold limits are determined, literally, by the amount of equipment involved. This is true for the front-end operation of a receiver or for a long string of bidirectional amplifiers in a tunnel. Each element of the system, be it a gain block or passive network, adds its bit of noise. Cumulative noise will ultimately desensitize a system to the point of unacceptable performance. Fortunately, in most modern equipment designs, a great number of blocks must be cascaded before "noise build-up" begins to approach practical sensitivity thresholds.

Desensitizing noise is manmade and external to the system. *Power line noise*, which can take many forms, is often broadband enough to affect more than one radio communications service si-

multaneously. *Impulse noise*, such as that generated by automobile ignition systems, is another common form of desensitization to VHF and UHF receivers. Enough noise of these types will effectively kill a system's response to intended signals. A receiver or amplifier will effectively shut down in the presence of strong noise because of bias shift in the input stages.

Noise: An analogy

Consider a ball game during which you see the hot dog vendor, maybe 150 feet away—too far to get his attention. You can't yell loud enough over the noise of the crowd. So you get the attention of someone 50 feet away and ask him to pass it on. Here, we have *ambient noise* (the crowd) and *gain blocks* in the form of two or three "pass it on" volunteers. Sound loss between each volunteer is about equal to each one's "yelling volume." You are just about to deliver your hot dog order when a fan between volunteers 2 and 3 begins to shout loudly at the umpire. The fan's outburst becomes *additional noise* disrupting communications over one section of the path. Before the fan started yelling, there was *net zero gain*, with each volunteer contributing just enough "power" to overcome the loss in his section, or link, of the system. The added burst of noise was enough to disrupt communications.

This illustrates what noise can do in a communications system. Fortunately, communications equipment with guaranteed noise specifications gives us a bit more design control than we had over the hot dog path. The use of good "noise sense" and careful design procedures can lead to

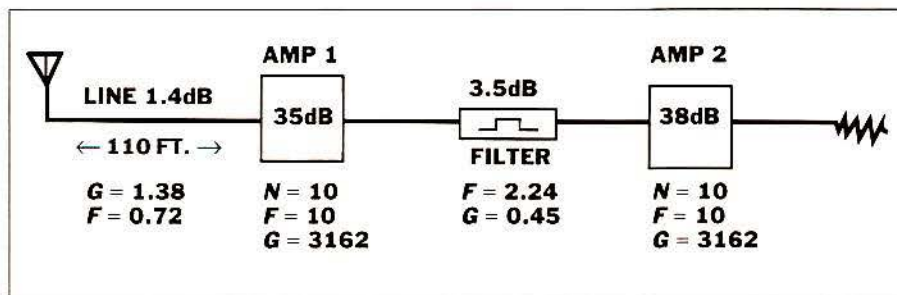


Figure 1. The example shows loss from 110 feet of Andrew Heliax 7/8" foam-dielectric coaxial cable, gain for two Andrew ACE repeater amplifiers, and insertion loss from a bandpass filter in cascade.

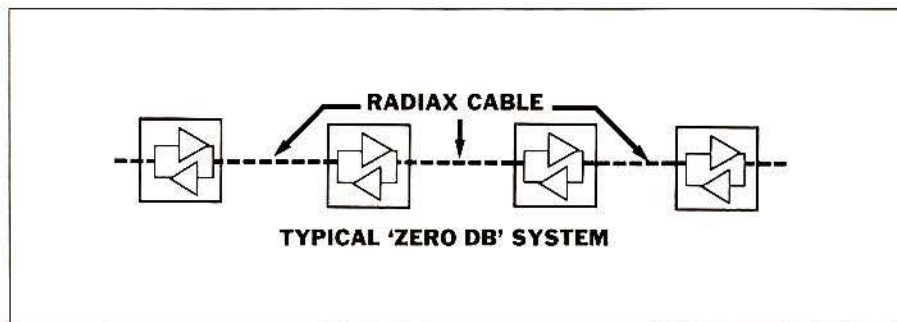


Figure 2. A "zero dB" tunnel system of four cascaded Andrew Radiamps line amplifiers and four sections of Andrew Radiax radiating coaxial cable.

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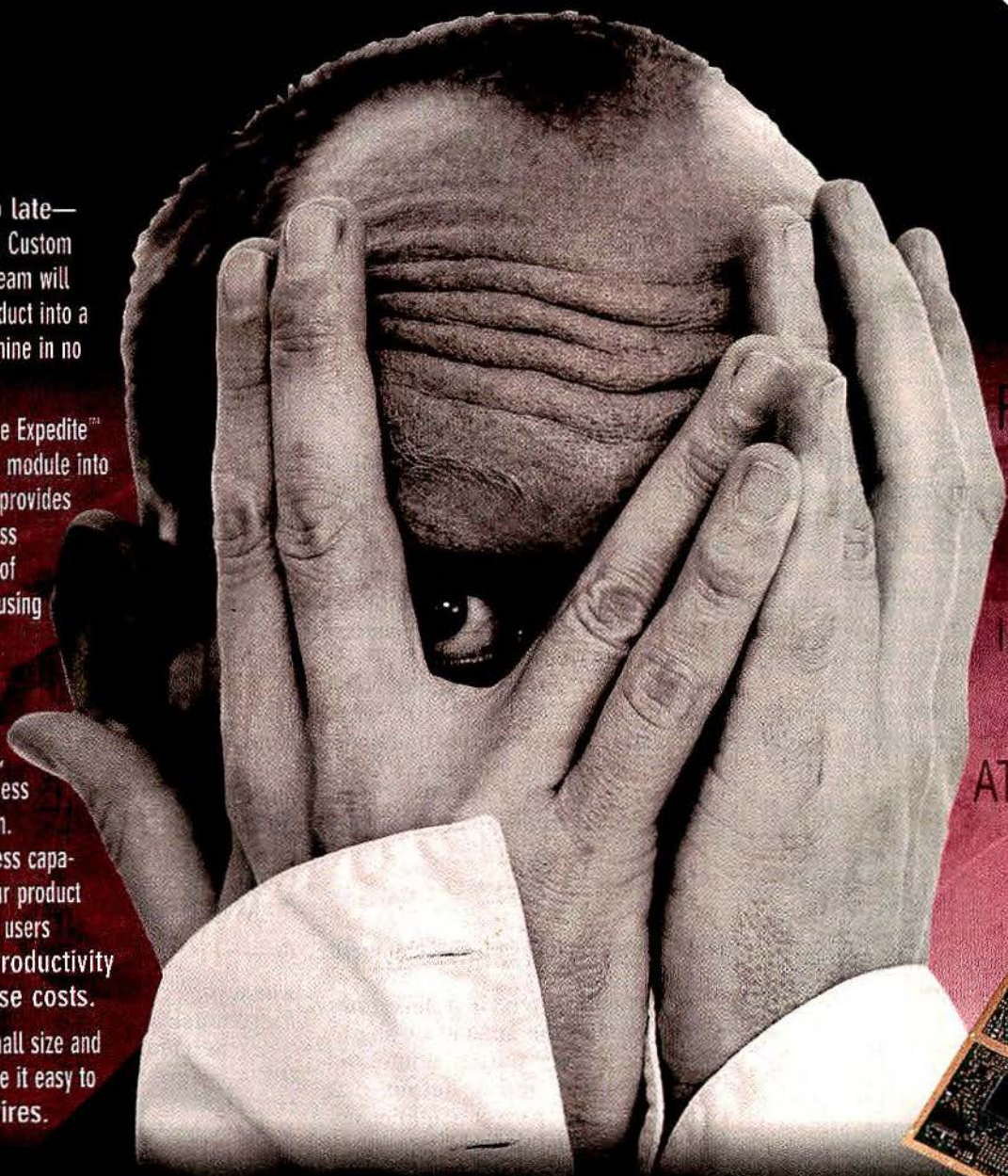
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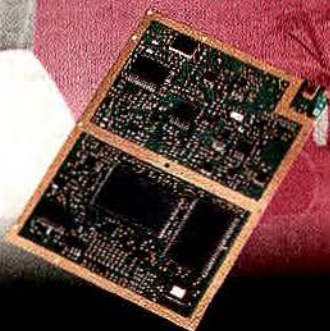
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Key points related to system noise

► **Noise temperature definition** — At a pair of terminals, and at a specific frequency, it is the temperature of a passive system having an available noise power-per-unit bandwidth equal to that of the actual terminals.

In the context of this definition, "pair of terminals" means the terminals of any active system under consideration, such as an antenna, transmission line, resistor or amplifier. "Active" does not necessarily mean *gain* in this definition (i.e., inert components have "negative gain," or loss, but the system as a whole is still active). Essentially, noise temperature is the ratio between noise at the terminals of a network and the noise that exists at the reference temperature (290°K) of a totally passive system.

► **Noise factor** — The ultimate sensitivity of an amplifier is set by the noise inherent to its input stage. A precise evaluation of a device's noise quality is obtained by means of its *noise factor*. Noise factor, as described below, is a *ratio* of powers. An amplifier's input impedance must closely match the source impedance for maximum power to be transferred to the amplifier.

The input termination (impedance) has an available noise power given by the expression:

$$P_n = (KTB)(\text{watts}) \quad [\text{Eq. 1}]$$

where

K = Boltzmann's Constant (1.38×10^{-23} joules per degree Kelvin).

T = temperature in degrees Kelvin. (Room temperature, 290°K, is used in most ordinary noise calculations.)

B = noise bandwidth in hertz.

A perfect, noiseless amplifier with gain G would have an output noise power over a given bandwidth of:

$$P_n = KTBG(\text{watts}) \\ = (1.38 \times 10^{-23}) (290)(BW_{\text{hertz}})(G) \quad [\text{Eq. 2}]$$

where

G (gain) is a multiplier.

BW = noise bandwidth.

Note: If $G = 1$ and $BW = 1\text{Hz}$, then

$$P_n = 4 \times 10^{-21} \text{ watts} \\ = -174 \text{ dBm}$$

Decibels above one milliwatt (dBm) is a logarithmic power term that appears frequently in noise formulas.

► **Example** — As shown in the following equation, the output noise power of a

"perfect" 40dB-gain amplifier (numerical gain of 10,000), operating over a 30kHz bandwidth, would be:

$$P_n = (1.38 \times 10^{-23})(290)(30 \times 10^3)(1 \times 10^4) \\ = 1.2 \times 10^{-12} \text{ watts} = -89 \text{ dBm}$$

A *perfect* amplifier generates no noise power of its own. A *real* amplifier generates internal noise because of thermal effects and molecular agitation. The numerical ratio of output noise power between real and perfect amplifiers is *noise factor* (F). Noise factor compares the noise power output of a model, *perfect* amplifier with the noise power output of a *practical* amplifier under the same gain and bandwidth conditions. It is described by the expression:

$$F = \frac{P_n}{KTBG} \quad [\text{Eq. 3}]$$

where

P_n = noise power output of a *real* amplifier.

$KTBG$ = noise power output of a *perfect* amplifier.

G = numerical gain.

► **Example** — Solving Eq. 3 for noise power, P_n , and with $F = 1$ for a perfect amplifier, the noise power output is $1.2 \times 10^{-12}\text{W}$. In other words, a perfect 40dB amplifier operating over a 30kHz bandwidth at room temperature would have a noise output of $1.2 \times 10^{-12}\text{W}$. A typical practical amplifier under the same conditions might have a noise power output of $1.4 \times 10^{-11}\text{W}$. Calculating the noise factor by Eq. 3 yields:

$$F = \frac{1.4 \times 10^{-11}}{1.2 \times 10^{-12}} = 11.7$$

(Note: Noise factor is *always* a numerical ratio.)

Noise factor, then, is a *multiplier* used to predict the amount of amplifier noise power output compared with the noise power output that would occur in a perfect amplifier under the same conditions.

► **Noise figure** — Signal-to-noise ratio (SNR), at the receiver's output is a critical element in the communications link. All information received, whether analog or digital, encrypted or "clear," is subject to confusion on the part of the interpreter. Accurate interpretation of information drives the necessity for measurable quantities. Noise figure, N , is a measurable figure of merit. In digital systems, the quantitative reliability measure is *bit-error rate* (BER). Bit-error rate is closely related to noise figure in a non-linear way.

The logarithmic expression of noise

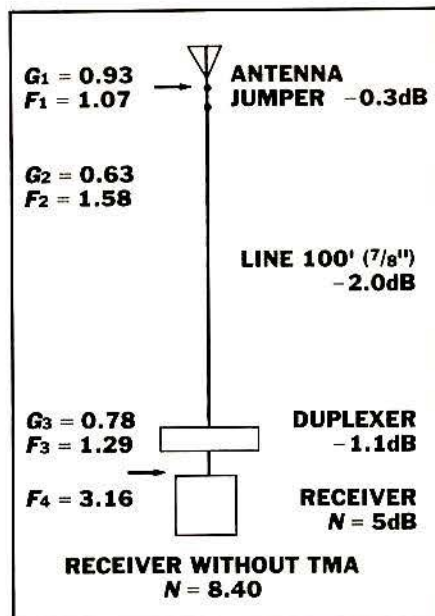


Figure 3. Each noise-contributing element between the antenna and the input to the receiver is calculated for the cascade noise factor formula.

factor is noise figure, or:

$$N = 10 \log F \quad [\text{Eq. 4}]$$

► **Example** — The noise figure, N , of the amplifier in the example above would be:

$$N = 10 \log 11.7 = 10.7 \text{ dB}$$

Note: Noise factor, F , is a ratio of *powers*, and *noise figure*, N , is the *logarithmic expression* of noise factor. **Noise figure** is more commonly used, especially for calculations.

The output noise power, in dBm, of a device is given by:

$$P_N = -174 + 10 \log BW + G + N \quad [\text{Eq. 5}]$$

where:

P_N = noise power in dBm at 290° Kelvin (room temperature).

BW = bandwidth in hertz.

G = gain in dB.

N = noise figure.

Essentially, the output noise power, P_N , of an amplifier is equal to the noise of the perfect amplifier plus a noise figure, N . Output noise power is generally expressed in **dBm**. Notice in Eq. 5 that noise power output varies with gain and bandwidth. Over the same noise bandwidth, and with the same gain and noise figure, noise power output of both heterodyne and non-heterodyne amplifiers is the same. However, there is a definite noise power advantage for heterodyne repeater amplifiers arising from the use of intermediate frequency (IF) filters to reduce system noise bandwidth. The

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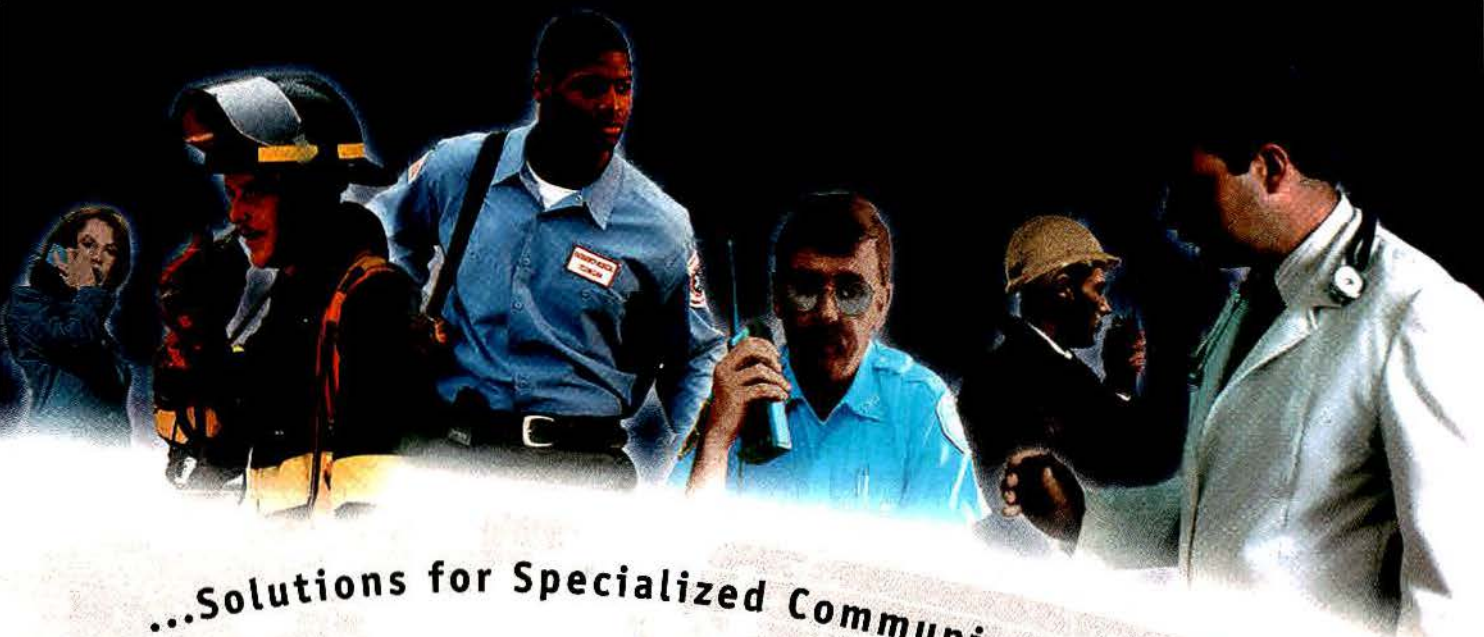
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effect of reduced bandwidth on P_N is apparent in Eq. 5.

► **Noise temperature** — Noise factor, noise temperature and reference noise are related by the expression:

$$T_r = (F - 1)T \quad [\text{Eq. 6}]$$

where:

T_r = device noise temperature.

F = is noise factor.

T = noise temperature, referenced to 290°Kelvin.

► **Example** — From this equation, noise temperature of the 40dB amplifier above would be:

$$T_r = (11.7 - 1) \times 290 = 3,103^\circ\text{K}$$

► **Sensitivity** — Sensitivity, like noise figure, is a measurable figure of merit. Sensitivity is defined as the smallest signal a network can reliably process. This definition specifies the strength of the smallest signal at the input of a network that causes the output signal power to be M times the output noise power, where M must be specified. $M = 1$ is generally used, although special applications, such as SINAD receiver measurements, use other values of M . Sensitivity is bandwidth dependent. At a source

temperature of 290°K and $M = 1$, the relationship of sensitivity to noise figure is:

$$\text{Sens.} = MKTBF$$

Note: ($N_{\text{fig}} = 10 \times \log F$), therefore sensitivity, in dBm is:

$$\text{Sens. dBm} = -174 + N + 10 \log (BW) + 10 \log M \quad [\text{Eq. 7}]$$

It can be seen that with a known bandwidth, sensitivity is directly related to noise figure.

Receiver system noise figure, consistent with known sensitivity, is calculated by solving Eq. 7 for N , as:

$$N = \text{Sens.} + 174 - 10 \log (BW) - 10 \log M \quad [\text{Eq. 7a}]$$

► **Example** — Assume a cellular receiver system is expected to process minimum signals of -116dBm (0.35µV). The term "receiver system" is used here because all cascaded elements ahead of the actual receiver affect the noise figure. From Eq. 7a, receiver system noise figure is calculated:

$$N = -116 + 174 - 10 \log 25,000 - 10 \log 1 = 14\text{dB}$$

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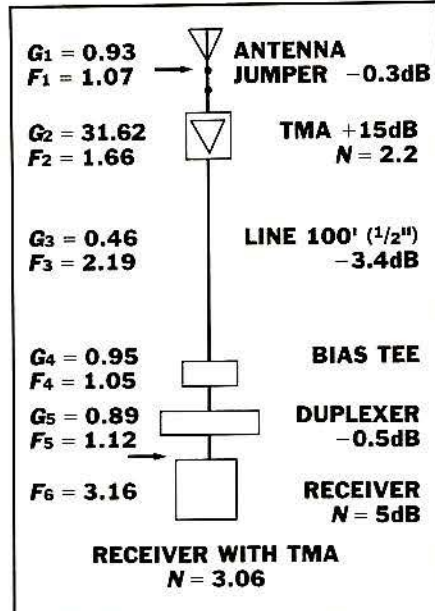
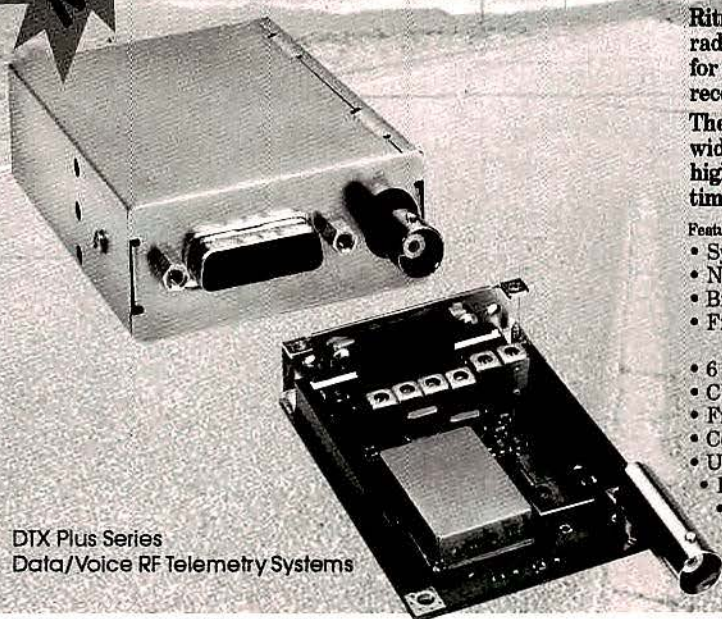


Figure 4. System noise figure calculations with a tower-mounted amplifier in the system.

margin "below threshold" reduces the noise figure to 8dB.

Thus, it can be seen that noise performance and gain are solidly linked in the challenging arena of RF amplifier design. As many RF

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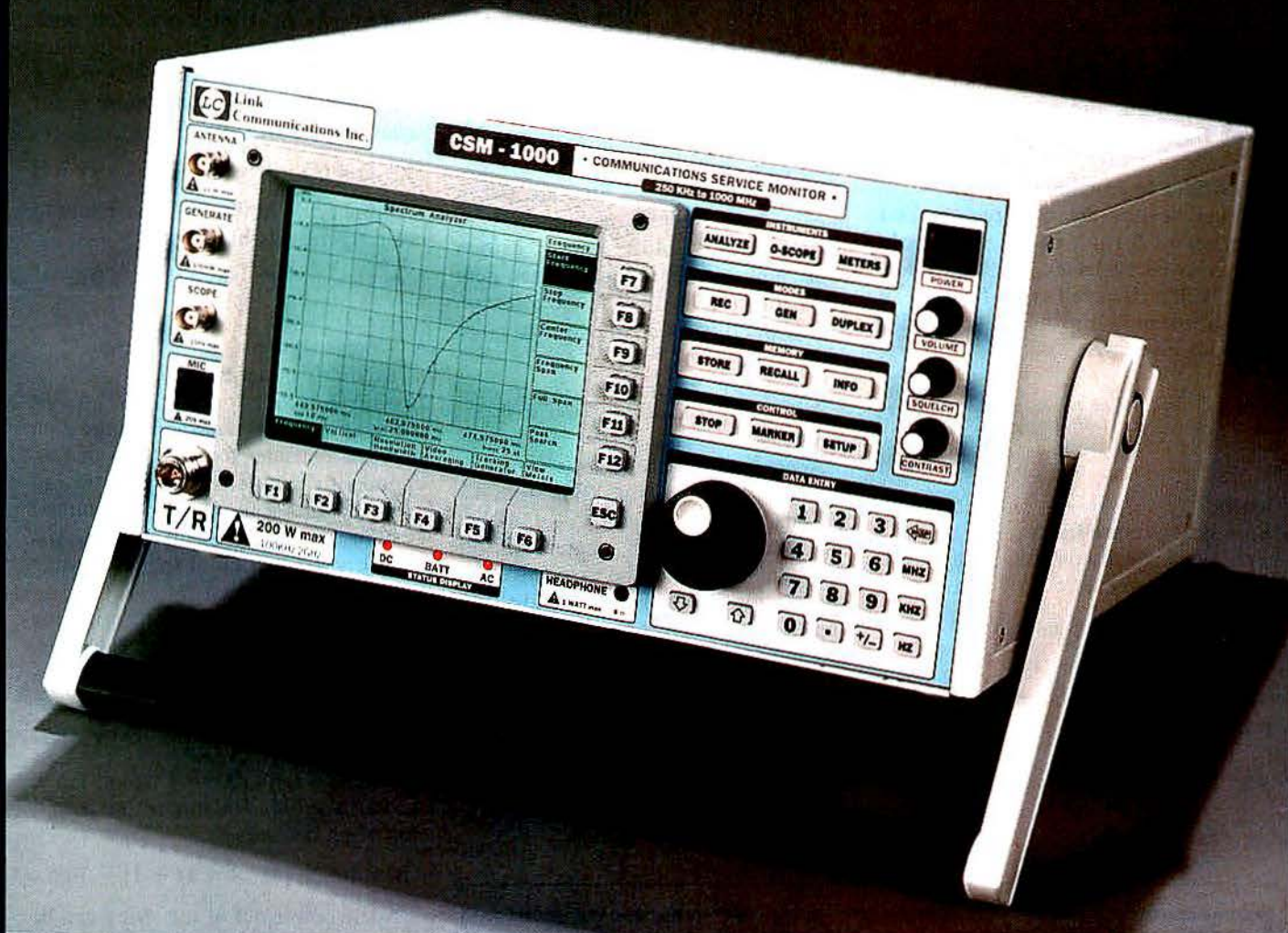
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designers have discovered, gain is an "empty parameter" and almost meaningless when considered by itself, without the correlation of a noise figure.

Amplifiers in cascade

When several devices are cascaded together to form a chain, the whole chain can be evaluated as a single element with a cascaded noise figure. The general formula for total system noise factor is given by:

$$F_s = F_1 + \left(\frac{F_2 - 1}{G_1} \right) + \left(\frac{F_3 - 1}{G_1 G_2} \right) + L \left(\frac{F_n - 1}{G_1 G_2 G_3 L G_{(n-1)}} \right) \quad [\text{Eq. 8}]$$

where:

F_s = system noise factor.

$G_1 \dots G_{(n-1)}$ = numerical gain of the individual elements,

$$G = \log^{-1} \left(\frac{\text{gain, dB}}{10} \right)$$

where: loss in dB is taken as a negative gain,

$$F_1 L F_{(N-1)}, F = \frac{1}{G}, \text{ for passive elements}$$

$$F_1 L F_{(N-1)}, F = \log^{-1} \left[\frac{N}{10} \right] \quad \text{for active}$$

elements, where N is noise figure.

As an example, 110 feet of 7/8-inch, foam-dielectric coax, two repeater amplifiers and a bandpass filter are shown in cascade in Figure 1 on page 32.

Cable loss is 1.4dB, amp #1 gain is 35dB, amp #2 gain is 38dB, noise figure of each amp is 10dB, and the insertion loss of the filter is 3.5dB. System noise factor is:

$$F_s = 1.38 + \left[\frac{10-1}{0.72} \right] + \left[\frac{2.24-1}{(0.72)(3,162.27)} \right] + \left[\frac{10-1}{(0.72)(3,162.27)(0.45)} \right] = 13.89$$

Accordingly, system noise figure of the string is $N = 10 \log 13.89 = 11.43$.

Thus, the noise figure, 11.43dB, of the cascaded string is greater than the 10dB noise figure of the first active element in the string. This is always true, and *how much* greater will depend on the "noise mass" of the string. Noise contributions of short jumper cables make little difference in the outcome. In more formal noise performance evaluations, all noise-contributing elements should be considered.

When a series of cascaded amplifiers,

each of gain G , is interconnected, with each driving a load equal to its gain (load = $-G$), the system is said to be a *zero dB system*. The system noise factor equation then simplifies to:

$$F_s = F_1 + (F_2 - 1) + (F_3 - 1) + \dots (F_n - 1)$$

Simplifying further and converting to noise figure, this becomes:

$$N = 10 \log [n(F - 1) + 1] \quad [\text{Eq. 9}]$$

where:

N = noise figure.

n = number of amplifiers.

F = noise factor.

For example, as shown in Figure 2 on page 32, consider four sections of cascaded line amplifiers and radiating cable operating in a "zero dB" tunnel system. Each line amplifier of 20dB gain drives a section of radiating cable having 20dB loss.

The uplink noise figure of each line amplifier is 9dB; the noise factor is, therefore:

$$F = \log^{-1} \left[\frac{9}{10} \right] = 7.9$$

From the zero dB noise figure, Eq. 9, the cascaded noise figure of the amplifier string becomes:

$$N = 10 \log [4(7.9 - 1) + 1] = 14.6$$

Noise power out of the string can be determined from Eq. 5 as:

$$P_N = -174 + 10 \log 25,000 + 20 + 14.6 = -95.4 \text{ dBm}$$

The string's performance is evaluated as if it consisted of only the last amplifier. SNR at the string's end is referenced relative to -95 dBm . If the amplifier signal output is $+30 \text{ dBm}$, SNR would be $30 - (-95) = 125 \text{ dB}$. From Eq. 7, sensitivity is -115 dBm . The effect of "noise build up" can be seen when the string's sensitivity is compared with that of a single amplifier acting alone, or -121 dBm .

Suppose instead of four amplifiers, the chain consists of 20 amplifiers. Again, the uplink noise figure of each amplifier in the string is 9dB, and the noise factor, F , of each amplifier is 7.9dB. Therefore, from Eq. 9, the noise figure of the string of 20 amplifiers is 21.4dB, and from Eq. 7, the string sensitivity is -109 dBm . Although diminished, the sensitivity of the string of 20 amplifiers is still well below the typical cellular contour level of -80 dBm . Noise "build up" is seldom a problem in properly designed amplifier and cable systems. Amplifier/radiating cable systems are possible over almost limitless



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distances, a point attested to by the long tunnel communications systems in use around the world.

Tower-mounted amplifiers, receivers

The following is taken from design notes on the uplink, or talkback, side of a 1,900MHz PCS system. Imagine you are looking over the shoulder of a designer confronting the usual problem of *talkback range vs. talkout range*.

The designer has established a base transmitting station (BTS) range of 4.5 miles. He must now determine if the mobile can talk back to the BTS receiver over the same path. Because systems of this type are usually talkback-limited, he has decided to use a tower-top amplifier (TMA) in the uplink receiver. The uplink gain budget from the mobile to BTS receiver is:

$$27\text{dBm} - 6 - 153 + 22 + X = -95\text{dBm}$$

where:

- 27dBm = 600mW portable output.
- 6 = portable antenna efficiency.
- 153dB = path loss mobile to tower.
- 22dB = antenna gain at tower.
- 95dBm = target receive level (note 20dB above minimum receiver sensitivity).

Solving, $X = 15\text{dB}$, or the amount of additional gain in the uplink path necessary to input -95dBm into the BTS receiver.

So, the designer determined a 15dB-gain TMA would offset the disparity between BTS talkout and talkback. Unfortunately, because of noise considerations, a 15dB-gain TMA *won't* deliver a 15dB path improvement.

Path improvement resulting from a TMA can be estimated by noise analysis of the receive path on a "before and after" basis. See the "before" diagram in Figure 3 on page 34, and calculate the noise between the antenna and the input to the receiver. Each noise-contributing element is calculated separately before combining it in the cascade noise factor formula. Starting at the input jumper:

From Eq. 8, calculation of individual element gains and noise factors:

$$\text{Input jumper, } G = \log^{-1} \left[\frac{-0.3}{10} \right] = 0.93 \text{ and } F = \left[\frac{1}{0.93} \right] = 1.07$$

$$100 \text{ feet of } \frac{7}{8} \text{ line, } G = \log^{-1} \left[\frac{-2.0}{10} \right] = 0.63 \text{ and } F = \left[\frac{1}{0.63} \right] = 1.58$$

$$\text{Duplexer, } G = \log^{-1} \left[\frac{-1.1}{10} \right] = 0.78 \text{ and } F = \left[\frac{1}{0.78} \right] = 1.29$$

$$\text{Receiver, with noise figure, } N, \text{ of } 5\text{dB, } F = \log^{-1} \left[\frac{5}{10} \right] = 3.16$$

Substituting gains and noise factors into Eq. 8:

Cascade noise factor

$$F_c = 1.07 + \left[\frac{1.58-1}{0.93} \right] + \left[\frac{1.29-1}{(0.93)(0.63)} \right] + \left[\frac{3.16-1}{(0.93)(0.63)(0.78)} \right] = 6.92$$

Therefore, noise figure of the system, *without a TMA*, $N = 10 \log 6.92 = 8.40$.

Now, refer to the "after" diagram (Figure 4 on page 36), and calculate system noise figure with a TMA. The path through the TMA has special support components, including a different duplexer and a bias tee. Also note the use of smaller, more economical (1/2-inch) feeder cable. Starting at the jumper, gains and noise factors of individual elements are:

Input jumper, $G = 0.93$ and $F = 1.07$, same as before,

TMA, with 15dB gain and noise figure, 2.2dB,

$$G = \log^{-1} \left[\frac{15}{10} \right] = 31.62 \text{ and } F = \log^{-1} \left[\frac{2.2}{10} \right] = 1.66,$$

100-foot, 1/2-inch line,

$$G = \log^{-1} \left[\frac{-3.4}{10} \right] = 0.46 \text{ and } F = \left[\frac{1}{0.46} \right] = 2.19,$$

bias tee,

$$G = \log^{-1} \left[\frac{-0.2}{10} \right] = 0.95 \text{ and } F = \left[\frac{1}{0.95} \right] = 1.05,$$

duplexer,

$$G = \log^{-1} \left[\frac{-0.5}{10} \right] = 0.89 \text{ and } F = \left[\frac{1}{0.89} \right] = 1.12,$$

receiver with noise figure, N , of 5dB,

$$F = \log^{-1} \left[\frac{5}{10} \right] = 3.16$$

and, by Eq. 8, cascade noise factor,

$$F_c = 1.07 + \left[\frac{1.66-1}{0.93} \right] + \left[\frac{2.19-1}{(0.93)(31.62)} \right] + \left[\frac{1.05-1}{(0.93)(31.62)(0.46)} \right] + \left[\frac{1.12-1}{(0.93)(31.62)(0.46)(0.95)} \right] + \left[\frac{3.16-1}{(0.93)(31.62)(0.46)(0.95)(0.89)} \right] = 2.02$$

Therefore, noise figure of the systems *with a TMA*: $N = 10 \log 2.02 = 3.06$.

Noise figure improvement amounts to subtraction of the before and after noise figures, or $8.40 - 3.06 = 5.34\text{dB}$. Five dB of noise figure improvement translates to the same amount of improvement in talkback conditions. In essence, the addition of a 15dB gain TMA yields a 5.3dB improvement in the talkback path.

The BTS receiver input calculation now becomes:

$$27\text{dBm} - 6 - 153 + 22 + 5.3 = -104.7\text{dBm}.$$

The BTS, designed to deliver -95dBm

to a mobile receiver at 4.5 miles, will receive a talkback level of -105dBm from mobiles at the same distance. Even though total range is less than on the downlink side, good performance at 4.5 miles is assured because the BTS receive level of -105dBm is 11dB above minimum receiver sensitivity.

In summary, with the parameters set forth, the BTS talkout range is 4.5 miles. Mobile talkback limitations cannot be completely overcome with a tower-mounted amplifier. Talkback calculations showed the need for 15dB gain in a TMA. Because of noise considerations, a realizable talkback enhancement of only 5dB is possible from a 15dB TMA. This will allow for a workable BTS receive input level of -105dBm from mobiles at 4.5 miles out. Path improvement depends heavily on noise factors and component losses but is rarely more than 7dB without the use of cryogenic amplifiers. Some service providers reduce, or pad down, the transmitter output to maintain parity with the best obtainable uplink. If exact parity is required, first calculate the best talkback range obtainable with a TMA and then design the talkout to match.

Noise characteristic is input-based

The noise characteristic of any device is fundamentally set by its input network, whether it is the base of a transistor or the first stage of a complex amplifier or receiver. When several components are cascaded together to form a network, such as a string of repeaters or a receiver system, the whole chain can be evaluated as a single element with an overall "noise factor." Noise figure is the logarithmic expression of noise factor. Noise figure and sensitivity are inextricably linked to the "front end," and no amount of extra design quality in later stages can make up for a bad "noise launch" at the input. ■

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Unlicensed microwave: Blessing or curse?

Engineering discipline and rigor should be applied to system planning and design to use unlicensed ISM band equipment to its best advantage.

By Stephen Bartlett

Use of microwave radios designed for the unlicensed industrial, scientific, medical (ISM) bands is becoming more popular in the world of microwave engineering. Many types of spread-spectrum, broadband radios have recently become available for use in the 2.4GHz and 5.8GHz unlicensed ISM bands as defined by FCC Part 15. These products offer potential solutions to unique wireless access problems caused by the loss of licensed spectrum and spectrum refarming actions recently taken by the FCC—or any situation where a need exists for a rapidly installed, low-cost wireless link.

These cost-effective, unlicensed radios can be both a blessing and a curse, however. Their cost-effective broadband application and ability to operate without a licensed channel make them a blessing. These systems are easily installed and can use conventional 2GHz and 6GHz microwave dishes requiring only coaxial cable, instead of the more-expensive waveguide.

The lack of coordination among users in the unlicensed spectrum, however, makes it a curse. Although these new technology systems can be useful for providing solutions to unique system problems, they are not the cure-all for the future of fixed wireless that many believe them to be.

Interference in spread-spectrum systems

The licensing and regulatory processes that protect the licensee eliminate many potential sources of interference in the licensed spectrum bands. In the unlicensed band, however, no interference protection exists, and the resolution of interference problems is pushed into the lap of the system owners, planners and



Photo courtesy of
Andrew Corporation

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engineers. Many system planners responsible for specifying and purchasing these systems have little understanding of how these systems actually work, and many have never been involved in designing fixed-site microwave systems. If this trend continues while the number of unlicensed systems increases, the unlicensed spectrum may become so noisy and unpredictable that many systems now working successfully today may become useless in the near future—especially in dense metropolitan areas.

Many of these unlicensed products are built with technologies based on one of two spread-spectrum designs: frequency-hopped spread spectrum (FHSS) and direct-sequence spread spectrum (DSSS). Both designs occupy a broad portion of the unlicensed spectrum. The difference between these spread-spectrum designs, however, is how they occupy that spectrum.

When unlicensed spectrum products were first introduced to the market, the initial buyers had the advantage—and luxury—of being first on the air, with few other spectrum users with which to contend. Many of these first systems used FHSS technology. FHSS radios transmit on a relatively narrow, instantaneous bandwidth while hopping several times a second between selected frequency assignments in a wide spectrum band. The FHSS receiver is synchronized to the transmitter's frequency-hop pattern and follows it for complete signal reception. After many of these systems began occupying the same unlicensed band, it was soon discovered that similar FHSS systems would often interfere with one another, even with 128 (seven code bits) or 256 (eight code bits) programmable hop-code combinations.

This isn't surprising considering the problem's statistics. It's easy to calculate the least number of FHSS systems having a better than even chance ($p > 1/2$) that any two of them will have the same hop pattern and interfere with one another. For n systems having m hop-code select bits, the following formula can be used to estimate the least number of users for a given interference probability:

$$\ln(p) = \frac{-n(n-1)}{2^{(m+1)}}$$

For an even chance of interference, $p = 1/2$, only 19 nearby FHSS systems would be required for any two of them to interfere using 256 codes ($m = \text{eight code bits}$), and only 13 nearby FHSS systems for any two to interfere using 128 codes ($m = \text{seven}$

code bits). Although this estimate does not consider the use of directional antennas (or transmit power differences that may reduce the probability for this type of interference), it does illustrate the high potential for interference that exists with only a few neighboring systems, regardless of the number of hop codes available.

DSSS radios use more of the unlicensed spectrum in their transmission than FHSS radios. Using a code-division, multiple-access (CDMA) scheme, each DSSS radio's baseband

signal is "chipped" with a unique spreading code. Each of the spreading codes in CDMA DSSS are *orthogonal*, meaning that *like* codes add, and *unlike* codes cancel. When a correct code is received, the receiver's matching de-spreading code provides signal gain, and the proper signal is detected. This orthogonal coding scheme reduces co-channel interference by providing a *code isolation*. This code isolation is a factor of the spreading gain (G) of the DSSS radio design. The spreading gain is the ratio of the spread bandwidth to



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the baseband data rate being carried by the radio. Low-data-rate, spread-spectrum systems have high gains with high code isolation. A high code isolation allows several radios to share a single spreading channel with low interference—a design principle used in PCS cellular systems. One of the risks with unlicensed DSSS radios is the tendency to push high data rates through the spread bandwidth. This may result in low spreading gains with low code isolation and a high risk of co-channel interference between DSSS systems.

One of the greatest concerns with using unlicensed radios is their lack of "noise immunity." These systems are susceptible to interference even if designed as spread-spectrum radios. The following types of interference can affect many spread-spectrum systems:

- ☐ **Narrowband interference (NBI)** (receiving non-spread-spectrum signals within the spread bandwidth).
- ☐ **Co-channel interference (CCH)** (receiving on-channel signals with different codes that cannot be effectively canceled).

- ☐ **Adjacent channel interference (ACI)** (receiving signals from an adjacent channel).
- ☐ **Intermodulation interference (IM)** (receiving signals generated by the sums and/or differences of two or more out-of-channel signals that result in various frequency products within the radio's channel band).

These various interference sources need to be considered (along with the radio's spread-spectrum design parameters) during the system planning and engineering phase. This is especially important for systems using unlicensed spectrum products.

Carrier-to-interference ratio (CIR)

Microwave system-link analysis considerations include:

- ☐ predicting path lengths, and potential obstructions and reflection points.
- ☐ estimating signal attenuation from transmitter to receiver to predict receive-signal levels (RSL).
- ☐ calculating the link's fade margin, which is the ratio of RSL to receiver's signal-threshold level.
- ☐ predicting the link's availability.

Systems designers using unlicensed radios need to consider another important parameter—potential interference on each link. To plan this effectively, designers must optimize the carrier-to-interference ratio (CIR) of each microwave link in the system. Spread-spectrum systems operating in high-interference channels should have an optimal CIR ratio of at least 5:1, or 7dB.

Many unlicensed DSSS radios are engineered to carry large data rates with respect to their spreading band. As the baseband data rate approaches the spreading rate, the processing gains become low and significantly reduce the radio's code isolation. In extreme cases, the radios may have less code isolation than the minimum required CIR (the 5:1 ratio noted above) and may become ineffective in distinguishing their intended signal's code from other codes used by neighboring radios sharing the same channel. This becomes a significant system design issue for users of these unlicensed broadband DSSS radios.

If these CDMA DSSS radios cannot prevent co-channel interference between themselves, then the system needs to be designed with a channel plan and frequency-reuse strategy. Some manufacturers of these broadband systems only offer one or two radio channel pairs in their product lines, which can make channel planning quite a challenge. Therefore, in the design of

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an unlicensed radio system, the spreading gain and optimal CIR are important parameters for determining the threat of destructive interference from radios within the system, as well as other user's systems in the same general area.

Optimizing link CIR

The best approach for reducing the potential for interference is to ensure that the overall system CIR budget is optimized by making it as large as possible for each link. Consider following these steps early in the design phase:

► **Only use radios that offer two or more channel pairs** — The more channel pairs that are available, the less the chance of CCH interference in the system. Ideally, adjacent, crossing or in-line paths should all be separated from one another by a frequency guard band.

► **Calculate the code isolation for the DSSS radios being considered ($10 \times \log(G)$)** — This will establish whether the radios can actually have an effective code isolation within the same band. Ideally, code isolation should be greater than the radio's minimum CIR ratio.

► **Consider the number of code choices available in the radio** — More code choices add flexibility to channel planning and an increased system tolerance to the large number of potential interfering systems in the same metropolitan area.

► **Obtain the unlicensed receiver's front-end filter roll off characteristics (dB isolation per MHz from center carrier)** — This system parameter determines the receiver's ability to reject ACI and IM products.

► **Calculate the RSL from the link budget for the signal of interest (SOI)** — This is the signal you want to receive. Also calculate any potential interfering signals (NBI, CCH, ACI, and IM sources—the signals you don't want to receive). The difference (in dB) between the SOI RSL and the sum of all the noise RSLs will establish the CIR estimate for each link in the system.

► **Consider alternating-link feed-horn polarities** — Ideally the interfering signal would be orthogonally polarized (90°) with respect to the signal of interest. This is an important consideration but needs to be well understood. Signal reflections may change a linearly polarized signal to elliptical or circular polarity. Reflections, especially over water, are often manifested as a varying amplitude and phase interference signal. Orthogonal, linear cross-polarization schemes have signal-to-interference isolations as high as 30dB, but with the variations due to reflections, this

isolation is significantly reduced. Therefore, it is best to use a more conservative estimate and to assume a circular-to-linear polarity isolation of only 6dB.

Organizing technical users

The new unlicensed radio systems have provided users with a number of system options that did not exist before. However, more engineering discipline and rigor need to be applied to system planning and design with unlicensed systems than ever was realized with licensed systems. Users of unlicensed

systems should consider forming a technical users group made up of the unlicensed product users in their local areas. This group could help regulate the local unlicensed spectrum, help resolve interference issues and prevent their spectrum from becoming unusable in the future. This user group could also help assist in future system planning as member systems grow. Increased use of these unlicensed bands has pushed a new set of planning and engineering responsibilities into the lap of many telecommunications directors nationwide. ■

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Make UHF trunking profitable

How does a commercial service provider integrate newly available UHF spectrum and technologies into a profit center?

Here's the view from the inside.

By Jeff Grazi

UHF trunking presents a unique set of issues that determine whether the system will operate efficiently, effectively and profitably. My company, based in Denver for the last 27 years, put up a trunked UHF system about four years ago using narrowband technology. This was added to our portfolio of community repeaters, cellular, paging and communications consulting services in the Denver and Colorado Front Range areas.

There are four main areas that the prospective UHF trunking operator should be aware of: licensing, equipment, technology and infrastructure.

Licensing issues

The FCC has basically issued two types of licenses in the UHF bands: an IG (decentralized) license and a YG (centralized) license. The commission is licensing both the 461MHz and the 451MHz parts of the band. (This split presents some challenges that will be covered later in the section on technology.)

The frequencies to which a licensee is assigned may be mixed. You may be assigned a 461MHz and a 451MHz frequency. They may also be mixed by type, IG and YG, depending on how densely populated and licensed your geographic area is.

Another issue, for IG licensees, is looking at co-channel users.

When you interact with your co-channel users, or interfere with them, you are going to have issues that you will have to work out. One of the nice things about the YG license is that you do not have co-channel users—it's an exclusive license.

Equipment issues

The 10MHz split in the band assignments

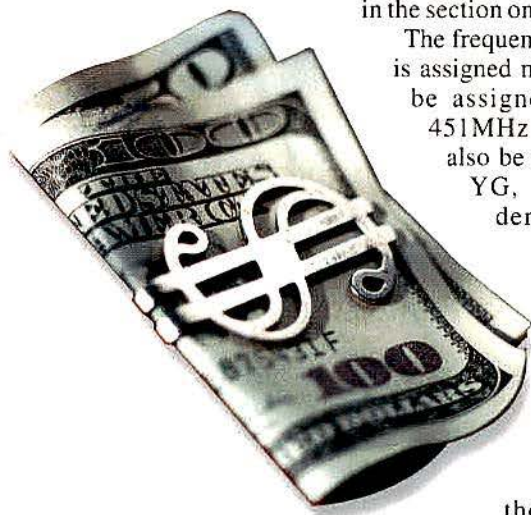
presents a unique set of challenges for the equipment. The transmitters will split with no problem, and combining is not a problem. On the receive side, however, it is much more difficult if you are installing a master antenna/multicoupler type of system. This will require splitting and creates problems such as losses incurred from that splitting.

Another challenge is channel monitoring. If you are an IG licensee, whether in the 461MHz region or the 451MHz region (or the 466MHz region, for that matter), you will still have to monitor the channel. YG licensees do not need to monitor. Most of the current trunking technologies use a *data burst* that is transmitted on the channel every ten seconds. If you are an IG licensee, you are going to have to hold off and monitor before those data bursts occur, which will hinder efficient functioning of the system.

IG and YG channels can be used together. When they are mixed, the home channels are placed on the YG assignments because there is no monitoring requirement, and then users can be trunked off onto the IG channels. Some of the current technology allows the equipment to look at busy channels, skip them if they are in use, and go on to assign other free channels.

Another challenge is that wide-area trunking requires that the system either be linked via a landline, microwave or some other means. We chose to use a microwave link, the 2.4GHz unlicensed spectrum (See "Unlicensed Microwave: A Blessing or a Curse?" page 40) and run a T1 between sites to link them.

► *Centralized and decentralized trunking* — Centralized trunking seems to be the most popular and most appropriate technology for these bands, and that's what we're using in Denver. Everything is done at one site, everything is controlled from that one site, and the repeaters are assigned from that singular

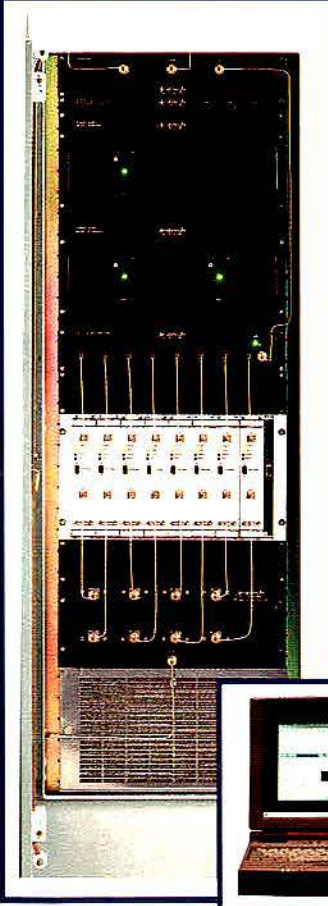


Grazi owns Grazi Communications, Denver. He has a degree in mass communications and electronics. He is a member of the Society of Broadcast Engineers, and he is a Fellow of the Radio Club of America. This article originated as a lecture presentation at the International Wireless Communications Exposition in March.


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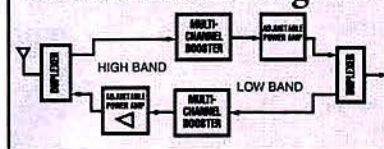
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point of view. If you use decentralized trunking, then the radio makes the decision, and it's a much slower system. Centralized trunking does work more efficiently.

Technology issues

Available technology for UHF trunking has been slow to turn out. For a long time, there was no technology available to allow handoffs. The big problem with multisite systems (we have three sites in the Denver area, for example), has been the requirement of the user to select which site he is going to use. The radio is not capable of making that determination. There is some technology, exhibited at the IWCE last March, for the next generation of UHF trunking that will allow automatic handoffs and will also allow automatic registration and unique user ID codes.

We are using the E.F. Johnson LTR format. We are examining going on to the Net-LTR system, which is an enhanced, more robust system with automatic handoffs and unique user ID. The standard LTR system seems to work as well as the 800MHz LTR has for the last 10 to 15 years.

The situation of having the users

select the site has been a drawback because the users are often unsophisticated regarding propagation, and they are generally unfamiliar with system operations. Unless you make it extremely simple for them, they may have a difficult time.

We are using compandered audio on our system, and we encourage those who come onto the system to use it. Most of the newer radios have this function available. It gives a much more intelligible system, giving users the feel of a wideband radio in a narrowband environment.

We have not found any problem going from wideband repeaters to the narrowband technology. Of course, we're running a hot preamp, using a multicoupler system and sitting on good, quiet sites. We try to keep our transmitter noise levels low. It's just a matter of engineering the system right. In terms of the audio recovery difference between wideband and narrowband, customers have not complained about volume or audio quality.

Infrastructure issues

► *The dynamics of interconnect* — New trunking technologies, unlike those

for the old 800MHz trunking systems, allow interconnect on any channel at any time in any place. That capability can be dynamic across the system. For example, in our area, if a user wants to use a site in Colorado Springs, which is 70 miles away from us, and wants to interconnect to a Denver telco line, we can allow that over the network—again, via microwave, T1 or some other system link. The system is no longer dependent on the interconnect being at the particular channel and at the site. Now the interconnects can be at any location in the system.

For interconnects we use USWest in the Denver, Colorado Springs and Boulder markets. We do run a T1 through a separate carrier, Qwest, from Denver to Colorado Springs to link the two cities, as well as for other applications. The hardware connects easily—all two-wire, standard signaling equipment that looks like a POTS line. In our system we use an overdial. Dial into the seven-digit number and then add either a two-digit or three-digit overdial, which is programmable. To access an outside line, the mobile unit keys up, gets dial tone, dials the number, and makes the connection. Timers can be customized

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to restrict time of day, time of week or day of week. The system is robust in terms of programming capability.

► **Coverage issues** — Our operation uses multiple sites in the Denver area: a downtown site that is on a tall building, a mountaintop site on Look-out Mountain and a third site in Boulder, a suburb 30 miles away. All three of these sites are linked, and this gives us the best of both worlds. The mountaintop gives us nice coverage up and down the Front Range, about a 30-mile radius up and down the north-south Interstate 25 corridor. However, it doesn't give us good coverage downtown, amongst the buildings or down in their sub-basements and so forth. What we have done is marry the two systems together. Now we can have a mobile operating 20 miles south of Denver that is communicating with a portable in the second sub-basement of a downtown office building. Linking the systems, and again having that microwave or land-line backbone link, allows us to do that because the system is programmable and it's all software-driven.

The repeaters in most metro areas do have dead spots, and so we try to add locations to them. And, as we build the system, we're starting to build it as a cellular-looking system. As technology improves, it will look and feel more like a cellular system with automatic handoffs, and the technology will have caught up with what the customers want.

Good planning makes for a successful system. Know the issues of your system, and it will be a reliable and profitable system with a minimum of hassle.

Selling the system

We've tried going out to the other mobile shops in town because we're the only service provider in Denver, presently, that has a UHF trunked system. We've gone to these other shops and offered them service on our system. That seems to be the best way to sell because, like many small telecom businesses, we don't have a huge sales force, and we're not out selling individual radios. Making the system available to other shops and users makes it much more profitable.

Only a handful of manufacturers support LTR for UHF. We use about three different brands. We are not restricting

shops. If they're selling "Brand X," we don't care, as long as they service and support it. This eliminates finger pointing when trying to distinguish between a system fault vs. an equipment fault.

To provide service to other shops, we basically offer an unlimited amount of airtime for dispatch for a flat rate. We sell to the shop at a wholesale rate of, say, \$5 to \$7. They turn around and sell it to the end user for \$8 to \$10.

Interconnect is a separate issue; we

sell that for quite a bit more, in the \$35 range. The shop does its own billing, and they pay us for the number of units. Right now, we are not keeping track of airtime. It is too difficult at this point, but as both we and the system become more sophisticated, we'll start keeping track.

We're also migrating a lot of our customers from our conventional over to the trunked channels because of the efficiencies. Finally, we are selling directly to end users as well. ■

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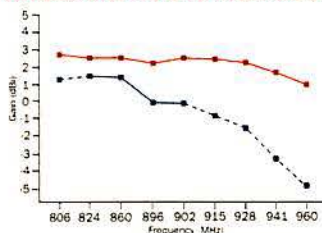
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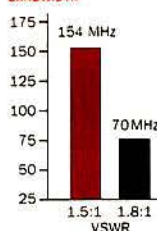
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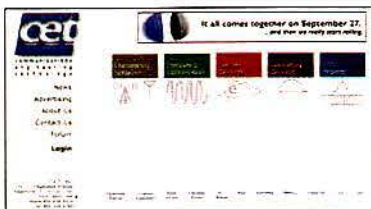


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www.ritron.com



Sinclair Technologies

Sinclair Technologies specializes in the engineering, manufacturing and distribution of antenna products and systems. Visit the Web site for more information on the newly released NCPS dual eight-channel receiver multicoupler.

www.sinctech.com/news/first.htm



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TX RX Systems

TX RX Systems is a division of the Bird Technologies Group. Visit the Web site for further information on multicoupler systems, signal boosters, antennas, duplexers, cavity filters and RF components.

www.txrx.com



Zetron

Zetron's site contains spec sheets and customer stories for its more than 100 wireless systems including radio/9-1-1 phone consoles, paging systems, trunked radio, SCADA and telemetry, utility networks and land mobile radio.

www.zetron.com

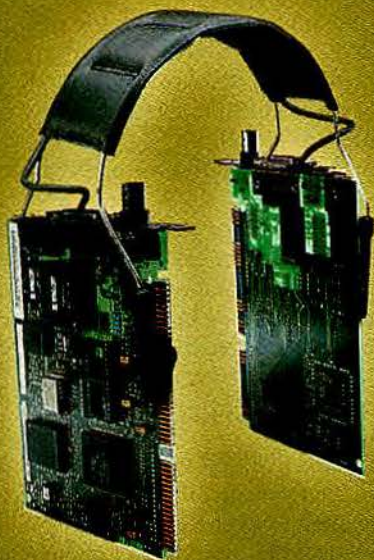
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Nextel acquires Chadmoore

One of the large analog specialized mobile radio (SMR) system operators, Chadmoore Wireless Group, has agreed to sell most of its assets to Nextel Communications. The agreement was announced on Aug. 21.

From its Las Vegas headquarters Chadmoore operates a U.S. network of two-way radio SMR systems. Among the assets are an estimated 4,800 800MHz channels.

Nextel began as a consolidator of analog SMR systems, which it later converted into digital two-way radio systems with a cellular base station architecture. It de-emphasized dispatch services and focused on selling handsets to business users for telephone interconnect that perfectly imitates cellular and PCS telephone service, with a twist—users can still use a form of dispatch service to call unit-to-unit (sometimes called "direct connect" or "executive intercom"). Also, Nextel handsets can receive paging messages.

Pending approval by the FCC and Chadmoore shareholders, the shareholders will receive Nextel shares anticipated to be valued at \$113.5 million, or about \$1.40 per Chadmoore share, subject to further adjustments at closing as defined in the agreement. Chadmoore shares were trading at 90 cents on Aug. 31.

Another \$46.5 million in Nextel

shares will be issued to Chadmoore and converted to pay liabilities and transaction expenses. Among other risks, Nextel will be assuming a possible FCC cancellation of Chadmoore licenses with a book value of \$6.2 million. The possible FCC action stems from a years-long march toward resolution of the status of construction deadlines that may apply to licenses that Chadmoore acquired. The affected licenses are connected with applications originally prepared by dubious SMR application filing services for entities participating in the old lottery system of awarding licenses.

Although Chadmoore's systems are predominantly analog, in years past it announced purchases of the same type of digital equipment used by Nextel. On the other hand, part of Chadmoore's business strategy has been to capture analog customers displaced from systems purchased by Nextel and then converted from analog to digital. Moreover, Chadmoore typically bills customers a flat monthly rate per mobile unit for dispatch service with an airtime surcharge for wireless telephone calls. Nextel bills by airtime used per handset or mobile unit. The difference can be substantial for digital dispatch service because airtime charges accrue for multiple units in a one-to-many call.

Additionally, Chadmoore was a beta-test customer for digital technol-

GTE, Motorola tap AVer-Tech for AVL installations

AVeL-Tech, a Canadian company headquartered in Laval, Quebec, has inked contracts with GTE and Motorola for separate automatic vehicle location (AVL) installations.

The GTE contract covers installation of an AVer-Net system for tracking 173 police and fire vehicles in Fort Lauderdale, FL. The system will run on a Motorola Datatac network and will coexist with Intergraph's computer-aided dispatch.

The Motorola contract covers the installation of an AVer-CAD computer-aided dispatch system for the Trinidad and Tobago police and fire Departments. The system will integrate Motorola's Centralink 9-1-1 system with AVer-Tech's AVer-Net AVL system and Radiogate message switch.

ogy made by ComSpace, Coppell, TX. Nextel has not indicated interest in ComSpace's digital-channel, multi-carrier architecture (DCMA) products, so the possible sale of additional DCMA products for use on the Chadmoore systems being acquired by Nextel seems doubtful. —D.B.

PROJECT 25: TOTAL SYSTEM SOLUTIONS



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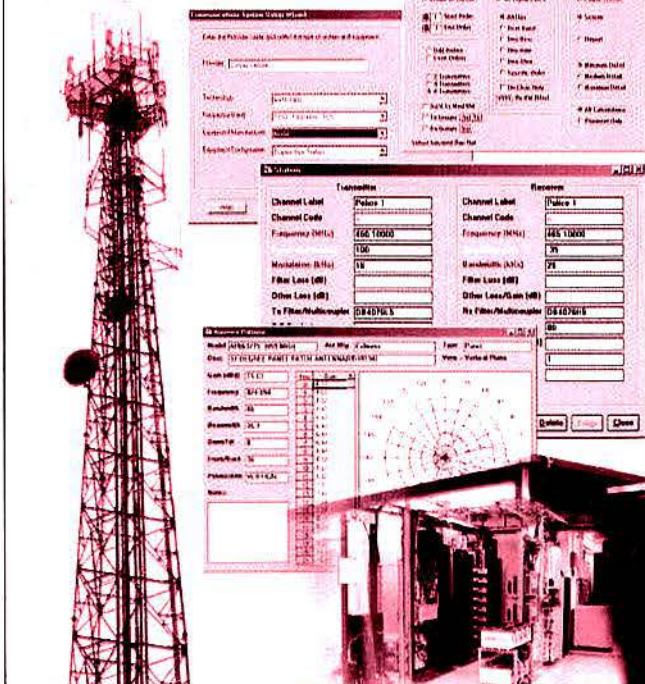
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M/A-COM teams with Kenwood for wireless systems products

M/A-COM, Lowell, MA, has entered into a strategic manufacturing agreement with Kenwood Communications, Long Beach, CA. Under the agreement, Kenwood will supplement M/A-COM's capability to manufacture software-based, digital portable radios for use in M/A-COM's OpenSky wireless private networks for public safety.



Vaughan

OpenSky integrates digital trunked voice and packet data over an Internet protocol-based network. It uses voice-over-IP and compression technology to improve voice capacity over traditional analog networks.

The software-based, digital portable radios support integrated data applications. Digital trunking voice features include voice grouping, priority scanning, pre-emptive emergency calls, late-call entry and dynamic reconfiguration.

"M/A-COM is extremely pleased to team with Kenwood, an industry leader whose commitment to developing and building the finest quality products is consistent with our own," said John Vaughan, vice president of M/A-COM's Wireless Systems Business Unit. "Many public safety, state, municipal and local agencies will greatly benefit from this collaboration."

The Opensky wireless IP network was most recently selected by Cumberland County, PA, for its public safety system.

Johnson to supply radios to FBI

The E. F. Johnson Company subsidiary of Lincoln, NE-based Transcrypt International has landed a contract with the U.S. Department of Justice (DOJ) for Project 25 mobile radios. Under that contract, the Federal Bureau of Investigation (FBI) has placed an initial order for units for its field locations.

Michael Jalbert, Transcrypt's chairman, said, "This is our first contract with the FBI, and it's a significant milestone for us. We believe that there is enormous potential for E.F. Johnson's digital mobile radios as the Justice Department embarks on its multimillion dollar program to upgrade its nationwide radio system to the APCO Project 25 digital standard."

The federal government has adopted the Project 25 standard as the digital wireless protocol for land mobile applications. Transcrypt is one of four companies offering Project 25 products. The federal government is making a transition from analog to digital wireless communications systems, with the move to the Project 25 standard expected to be completed by 2005.

The order from DOJ's Wireless Management Office (WMO) specifies Johnson 5300 series radios, which are backward-compatible with legacy encryption systems widely deployed in federal markets. The 5300 series provides multi-mode operation on existing wideband networks and on narrowband Project 25 digital networks.

WMO was created in 1998 to coordinate the development of a common wireless network for all DOJ agencies. The WMO was established to centralize oversight, management, financial management and procurement for the Justice Wireless Network. The WMO has conducted pilot studies in several major metropolitan areas to prove the viability of a shared DOJ system. The Justice Wireless Network system planning has been completed for more than 30% of DOJ wireless users and is now moving to the implementation stage.

—D.B.

News Notes

The California Highway Patrol's Los Angeles Communications Center is ready to go online with its new wireless 9-1-1 system, compliments of **Plant Equipment**. The system provides the telephone number of the device making the call to enable CHP to call back if calls are disconnected. **Erik Estrada** could not be reached for comment on how the system would have benefitted his character "Ponch" on "CHiPs."

In other California-related news, **Long Beach Gas & Electric** will update its existing wireless workforce management system from **Mobile Data Solutions** to a more current version of Advantex. It will manage about 60 mobile workers who perform routine maintenance and customer service work in the metropolitan Long Beach area.

Comsearch has sold its microwave path design software to **Dolphin Telecom** of Germany for about \$550,000. The software licenses will be used to support Dolphin's TETRA network in Germany.

Tesco Technologies reached an agreement with **Adaptive Broadband** to market and deliver Adaptive's Ab-Access fixed wireless broadband product to a variety of local exchange carriers and wireless Internet service providers. "Our opportunity with the fixed wireless broadband market is so huge, that our biggest challenge is deploying resources to maximize our market coverage," **John Skoro**, Adaptive Broadband's senior vice president of sales and market development, said.

So much for smoking in the boys' room. **Tewksbury High School**, MA, has installed the **Motorola RemoteVU** integrated digital video system that enables remote monitoring of the school by police and other emergency services. "If a student is injured at a sporting event, or a fire alarm is activated in the school, we no longer have to wait until we're on the scene to assess the situation," Tewksbury Police Chief **John Mackey** said.

Contract news:

Radio Frequency Systems has been awarded a contract to enhance the MTRC metro system in Hong Kong to include 3G mobile wireless service ... **Dataradio**, has been awarded a contract for a multisite, 800MHz mobile data network for the municipality of Anchorage, AK. The network will provide officers with CAD, records management, NCIC access, and automatic vehicle location. **Mobex Communications** and **Cerulean Technology** were also involved in the deal.

This month's sign that RF waves may cause brain decay: A freshman at William Patterson University, Wayne, NJ, has vowed to go a year without speaking. His only means of communication: a **Motorola Talkabout T900**. With an idea this absurd, it's a good bet he didn't have much to say in the first place. —MH

SBC deal boosts SpectraSite to 9,000 towers

In a transaction worth \$1.3 billion, the SpectraSite Communications subsidiary of SpectraSite Holdings, Cary, NC, will lease 3,900 communications towers owned by SBC Communications, with the right to sublease them. In addition, SpectraSite has the option to purchase the 3,900 towers at the end of individual tower lease terms (on average, about 27 years) at a present value of \$251 million. The transaction gives SpectraSite the largest tower portfolio in the 50 largest U.S. markets. The transaction gives SpectraSite control of 9,000 towers in the United States.

Consideration for the transaction includes \$983 million in cash and \$325 million in SpectraSite common stock. The transaction includes a five-year agreement for SpectraSite to build an estimated 800 new towers for SBC.

SBC Wireless will sublease space from SpectraSite on the towers for \$65.5 million per year with annual lease-rate escalators. The transaction is expected to close in increments, beginning in the fourth quarter.

The SBC towers are concentrated in

Los Angeles, San Diego, San Francisco, Boston, Washington, Baltimore, Philadelphia, Dallas, St. Louis, Las Vegas, Chicago and Cleveland.

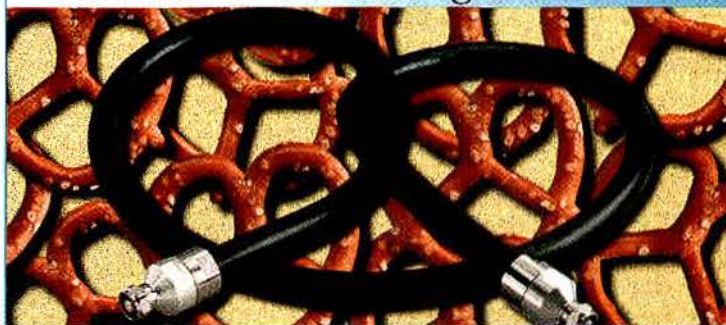
"The build-to-suit component of this transaction represents tremendous long-term value for SpectraSite," said Stephen H. Clark, president of SpectraSite.

Lawrence B. Sorrel, SpectraSite's chairman and a general partner of SpectraSite's largest investor, Welsh, Carson, Anderson & Stowe, added: "SBC's investment in SpectraSite is a strong sign of support in SpectraSite by yet another industry leader. SBC is the third substantial carrier transaction that SpectraSite will complete."

"The SBC portfolio was highly sought after among the major consolidators in the tower industry, and SBC was the first carrier to have the opportunity to truly evaluate the progress and overall performance of the tower companies from each of the prior carrier deals. The fact that SpectraSite was selected from a competitive field validates that we are the leading operator, and the partner of choice for carriers," Stowe said. —D.B.

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CABLE

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Relm fights fires arboreal and financial

What's bad for the nation's forests is good for Relm Wireless. The West Melbourne, FL-based radio communications equipment manufacturer received an "emergency order" worth \$320,000 for 530 radios on July 27 and shipped them the next day. U.S. Forest Service workers received them the following day. Relm has a contract to supply the Forest Service, which is fighting fires on more than four million acres of forest.

On Aug. 30, the company announced that the vast number of forest fires has resulted in \$1.9 million worth of additional orders that are expected to be shipped during the third quarter. Relm filled emergency orders for 1,400 radios in August.

However, for the three months ending June 30, Relm reported losing \$542,000 on \$5.2 million in sales.

Relm has retained the investment banking firm of Janney Montgomery Scott as a financial advisor as the company considers whether to sell all of its

assets, merge with another company, recapitalize or enter into a joint venture. Janney will also explore additional financing alternatives and other sources of working capital.

Relm's president, David P. Storey, said that the Forest Service sales will help to increase revenue, as will ex-

pected sales and shipments of inventory acquired from Uniden America's Private Radio Communication Division and shipments to the U. S. Army under an order placed in June.

The company's expense ratio may improve since it contracted earlier this year for manufacturing services and moved to smaller quarters.

"We are continuing to develop our APCO 25-compliant digital products, planned for introduction early in 2001," Storey said. "These new product and revenue opportunities, combined with serious cost reduction measures, we believe, will yield improved financial performance in 2001." —D.B.



Com-Net Ericsson, Dataradio make strategic alliance

Com-Net Ericsson Critical Radio Systems, Lynchburg, VA, and Dataradio, Atlanta, have signed a letter of intent for the creation of a strategic alliance to provide and integrate Dataradio's wireless data products and systems through Com-Net Ericsson's worldwide distribution channels.

In addition to Com-Net Ericsson offering Dataradio products and systems, the two companies intend to work together to develop new products for combined voice and data networks.

The companies will interface through Com-Net Ericsson's newly formed Data Systems division, a multifunctional organization dedicated to serving the data needs of today's land mobile radio market, from consulting services to the delivery of complete, integrated working systems.



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❑ **Com-Net Ericsson, Marconi Communications, Simoco and Nokia**, among others, want to introduce TETRA products in the United States for public safety and commercial users. **Motorola** and perhaps other holders of intellectual property rights connected with TETRA can prevent TETRA products from being sold in North America. Motorola has said that it recognizes the strength of the public safety community's desire for interoperability. It is reluctant to facilitate the introduction of digital radio technology that doesn't meet the U.S. Project 25 standard for interoperability, although it has a large share of the worldwide TETRA market and could offer such products itself. Our online story explains how the matter is being resolved within the standards process and how long it may take.

❑ **USMSS** is ready to help dealers find new opportunities when it makes presentations at the Oct. 4-7 Private Wireless Spectrum Management Conference and Exposition (see page 8). USMSS is finding ways to overcome the "Motorola factor."

❑ "Orthogonal multiplexing" may boost mobile data transfer rates, including voice-over-IP. Read what **Joseph Leonard**, president of **ElectroCom Systems**, and **Ernie Hofmeister, Ph.D.**, chief technology officer of **Com-Net Ericsson Critical Radio Systems**, have to say about the new technology from **Flarion**.

❑ An acquisition by **Motorola** brings **Printrak**, its 600 employees and its software and related services into the fold at the manufacturing giant. Motorola executive **Robert L. Barnett** explains why the Printrak acquisition will help public safety customers.

❑ **Southern Linc** has signed up its 200,000th customer as it scores a hefty percentage growth over last year.

❑ **Transcript International** lost \$2.6 million in the second quarter. Chairman **Michael Jalbert** explains the loss, offers reasons why the future holds better results, and sets an ambitious revenue target for 2005.

❑ **Datamarine International**, still the subject of takeover talk, saw its land mobile product sales increase a little last quarter, while its marine communications and marine instrumentation product sales sank. Find out what else the company is selling.

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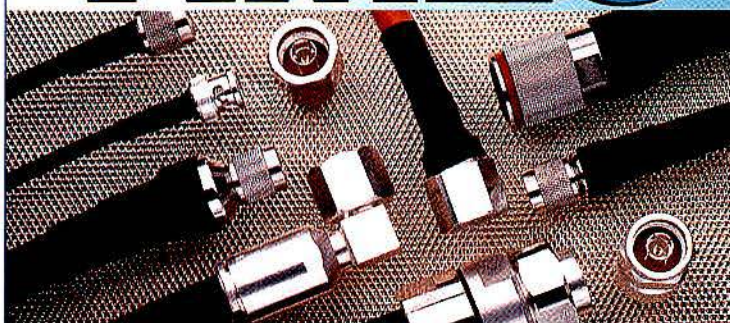
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Mobile antennas

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The ASP-7925LF conversion and replacement antenna and the K-749LF replacement NMO-style base from **Antenna Specialists** use leaf-spring contact assemblies to replace the push-pin assemblies, improving cold-weather performance. The broadband antenna covers the 806MHz-869MHz frequency range without tuning and has a $\frac{5}{8}$ -wavelength upper whip and

a quarter-wavelength lower section, providing 3dBd (5dBi) of omnidirectional gain. The rugged, one-piece whip, including phasing coil, stands 13.4" high and is constructed of stainless steel with a satin finish. Typical installations have an omnidirectional pattern when roof-mounted with a minimum 12" ground plane and a VSWR of better than 2:1 across the entire bandwidth. New or replacement installations using a KSM766 fully shielded NMO mount will improve the antenna's VSWR performance to 1.5:1. It can handle 100W of power.

CIRCLE (351) ON FAST FACT CARD

UHF antennas offer NMO shielded $\frac{3}{4}$ " mount

Hirschmann's land mobile antennas cover the standard land mobile communications bands from 30MHz to 960MHz. Quarterwave, $\frac{5}{8}$ -wave and collinear styles are available. The rooftop and fender-mount antennas are compatible with the industry-standard $\frac{3}{4}$ " NMO-style. The 406MHz-512MHz UHF band antennas (MCA-310 to MCA-690 series)

are available in open- and closed-coil collinear designs. The rugged stainless steel whips are designed to withstand adverse conditions. They are rated to 150W power handling capability. The sealed, weather-resistant, closed phasing coil provides noise-free operation. The 5dB models require no ground plane.

CIRCLE (352) ON FAST FACT CARD

Antenna features low visibility

The Phantom GPS/UHF dual-band antenna from **Antenex** features low visibility, wide bandwidth and a low-angle radiation pattern. The GPS mounted inside the ABS-molded housing with the antenna features an active 27dB



LNA. The housing fits into a standard $\frac{3}{4}$ " hole and mounts with the supplied locking washer and bolts. RG58 cable is supplied

with the UHF antenna, and RG174 is

supplied for the GPS. The whipless design allows car washes without removing the antenna. The antenna also features field diversity, offering simultaneous sensitivity to electric and magnetic fields.

CIRCLE (353) ON FAST FACT CARD

Antennas ensure radiation efficiency

Radiall/Larsen Antenna Technologies' 200MHz mobile antennas feature the Kulrod plating system that ensures radiation efficiency without the loss of power through rod heating. The antennas come in quarterwave, halfwave and $\frac{5}{8}$ -wave designs for coverage in the 220MHz-225MHz band. The antennas handle 200W of power and offer a VSWR of 1.5:1 or less. The heavy-duty base coils are air-wound for low RF loss. The optional shock spring is internally shorted with flexible insulated wire to eliminate distortion. The Makroblend shells are UV and chemical resistant. One model is the KG antenna, a low-impedance design in a glass-mounted antenna.

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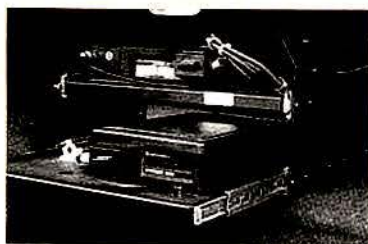
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READERS' CHOICE

Of the new products in the March 2000 Issue, this one generated the biggest reader response. For more information on this product, circle the corresponding Fast Fact number on the card found in the back of this issue, and mail the card to us.

Radio shelf offers clean, easy installations



Gamber-Johnson's trunk-mounted radio shelf provides clean installations and easy access. The shelf is designed for mounting radios in the trunks of Ford Crown Victorias. It offers a sturdy, non-flammable steel construction and a safety snap pin with lanyard. The no-holes-bored design makes installation easy with no drilling required. It can be ordered with a single shelf or double shelf.

The second shelf can be added later as more mounting space is needed for additional equipment. Fully extendable ball-bearing slides allow gliding shelves to be removed for easy installation and equipment repair. The single shelf weighs 21.4 pounds; the double shelf is 29.6 pounds. The trunk-shelf also has a large mounting surface, featuring shelf dimensions of 13 1/4" x 24". It is also designed with 4 3/4" of space between shelves to accommodate popular radios.

CIRCLE (500) ON FAST FACT CARD

Active headset compresses noise to 84dB

Wolf Ears active hearing protectors from Gentex offer electronic circuitry that senses impulse noise and compresses the noise to 84dB. An amplifier circuit allows conversations and range commands to be heard at normal levels when impulse noise is not present. The headset is equipped with off/on/amp selection of operation modes and a gain adjust that allows adjustment to increase sensitivity for low level sounds by a factor of two. With gain at full 96dB, on-mode threshold is 90dB and amp mode is 96dB.

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Multi-Channel Remotes for Kenwood -80 and -90 Series Radios



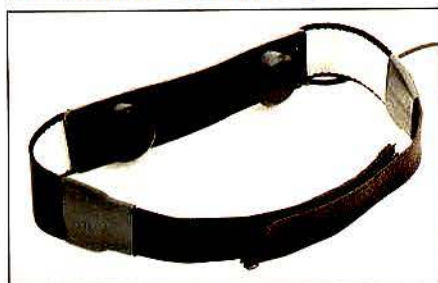
CPI's MCR411A remote and MCP401 termination panel allow two wire (four-wire optional) control for the -90 series radios. The TSR412A and TSP402 are used with the -80 series radio. Channel up and down, group up and down, nine character alpha channel identifier, scan, monitor, intercom, and front panel transmit are all standard features. No programming cables or software are needed. Radio is dedicated to remote operation. Many systems are available for other radios. Please call or visit our website for additional information on this or other CPI products.



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CIRCLE (45) ON FAST FACT CARD

Throat mic adapts to noise environs



Otto Communications' throat microphone is equipped with an earphone and acoustic tube and can be adapted to low- and high-ambient noise environments. The microphone has an adjustable elastic strap and flexible bar and includes a standard 80mm PTT. It has an electret mic element and weighs 0.13 pounds.

CIRCLE (402) ON FAST FACT CARD

Microwave radio offers menu-driven interface



Telepoint's Diginx Wireless Delivery System is a point-to-point and multi-point microwave radio that offers a menu-driven user interface. The radio can support voice, fax and data input rates from 32kbps to 512kbps. The system operating frequencies are programmable at 5/6.25kHz or 10/12.5kHz increments. The radio's user interface includes a 4 × 20-character LCD and nine LEDs. System parameters can be monitored and altered from the front panel.

CIRCLE (403) ON FAST FACT CARD

Fleet software tracks repair information

Fleet Maintenance Pro version 7.0 from Innovative Maintenance Systems tracks and organizes maintenance information for vehicles and equipment. The program runs on Windows 98/95/NT/2000, and it tracks year, make, model, mileage, vehicle identification number, purchase information, registration data, and loan and lease information. It also keeps track of repair, inspection and user-defined maintenance cycles.

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CIRCLE (46) ON FAST FACT CARD

Computer mount carries two-year warranty



The **Dataradio** Transportable Unit incorporates a Dataradio Mobilpac or Gemini mobile radio modem, a Panasonic CF-47 laptop, and an antenna and magnetic mount. Foam padding, in a wrap-around design, protects the laptop. All equipment is mounted to an internal panel in a deep-drawn, 6063-T5 aluminum-alloy tongue-and-groove extrusion case. The Transportable Unit carries a two-year limited factory warranty.

CIRCLE (405) ON FAST FACT CARD

Attenuator offers convection cooling



The Model 1000-A series of portable, RF attenuators from **Bird Component Products** offer 1,000W convection cooling. Attenuation values from 3dB to

30dB are available. Specifications for the attenuators include a frequency range of dc to 1GHz at 1:1 maximum VSWR. Connector options comprise TNC, N and 7/16 male and female.

CIRCLE (406) ON FAST FACT CARD

Software facilitates 700MHz bidding

Comsearch's Auctionplanner is a planning program for potential FCC auction bidders to help identify current users in the 700MHz spectrum range. The software offers information on spectrum licenses in standardized, easy-to-use formats. Population statistics and other possible interference criteria are featured in the program. The software has mapping capabilities and extensive databases and allows potential bidders to see what portions of an auction-designated area are available, partially encumbered or completely encumbered. Using detailed census tract data for the United States, the software can tell bidders what percentage of the population is reachable with the 700MHz frequency band.

CIRCLE (407) ON FAST FACT CARD

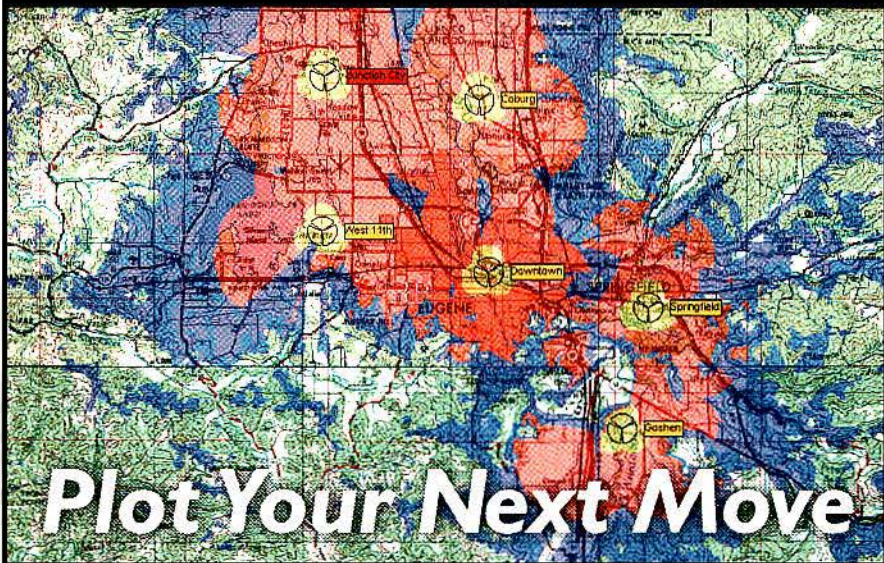
Converters protect against overvoltages



The series 1640 dc-to-dc converters from **Wilmore Electronics** are designed to power sensitive electronic equipment from either 24V, 36V or 48V batteries. The converters operate from 20Vdc to 56Vdc and offer an isolated and regulated dc output. They operate in -30°C to 60°C temperatures, and they protect against input-voltage polarity reversal, output short circuits and output overvoltages. The converters are available with voltages from 5Vdc to 28Vdc.

CIRCLE (408) ON FAST FACT CARD

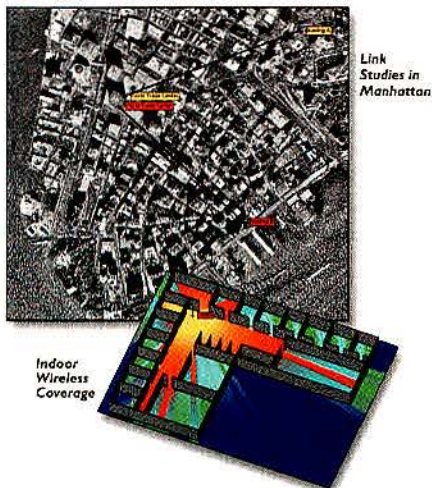
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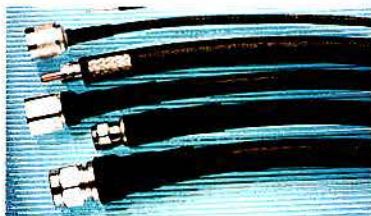
CIRCLE (33) ON FAST FACT CARD

Trunking system facilitates five sites

The Smartstart wide-area trunking and networking system from **SmartLink Development** is designed for campus and industrial facilities with wide-area service needs of five sites and 20 channels. The system comes pre-packaged with the necessary equipment to provide networking and control functions for as many as three sites and 10 channels. A software expansion option is available for an additional two sites and 10 channels. Smartstart offers frequency transparency, real-time networking, cross-protocol communications and cross-frequency communications.

CIRCLE (409) ON FAST FACT CARD

Cables meet MIL requirements



Times Microwave Systems' LLSB military-qualified, low-loss, low-smoke coaxial cables have been approved to the latest requirements of MIL-C-17 "G" for crosslinked military coaxial cables. The cable is offered in sizes from 0.200" through 1.670". A line of connectors and strip tools is available that offer reduced installation time and consistent performance.

CIRCLE (410) ON FAST FACT CARD

Combining filters eliminate multiple antennas

STI-CO Industries' array of combining filters connects several devices operating in the same frequency range to a single antenna. Applications include operating two transmitters on a single antenna providing data and voice capability. AVL and GPS devices, in-car computers, cellphones, multiple radios, repeaters and similar components benefit from filters by avoiding additional antenna installations. The model FLT-800/800 operates over the 800MHz-896MHz frequency range and supports typical cellular/trunking devices. The model FLT-150/150 is available in two VHF versions. The first version has a 35MHz bandwidth operating between



140MHz and 175MHz. The second has a narrow passband (about 10MHz) that can be set anywhere between 130MHz and 225MHz. The model FLT-450/450 operates in the UHF range. It is narrowband at 40MHz bandwidth.

CIRCLE (411) ON FAST FACT CARD

MDT mounts feature telescoping support

TCB-series mounts from **Havis-Shields** have a telescoping base with articulating swivel arms that allow positioning of a computer where it's easy for the driver or passenger to use. The mounts are made from welded tubular steel and are suited for use in public safety vehicles. TCBs

mount independently of an enclosed console by attaching directly to the vehicle's two front-seat bolts on the passenger side. Mounting height is adjusted by raising or lowering the pole, and secured by tightening the lock knob.

CIRCLE (412) ON FAST FACT CARD

Radio works in Smartnet, Project 25

The 5300 analog and digital mobile radio from **E.F. Johnson** provides Smartnet-, Smartzone- and Project 25-compatible interfaces to meet the needs of state, local and federal government users, and to support business, industrial and public safety applications. With backward compatibility, the mobile offers the capacity to communicate in narrow and wide channels and to operate in either digital or analog mode. This allows the mobile to switch from communications between Smartnet, Smartzone

and APCO 25 approved equipment to conventional FM equipment with a turn of the channel knob. The mobile features alphanumeric display, DTMF compatibility, rotary knobs, DES and DES-XL option and optional remote mounting.



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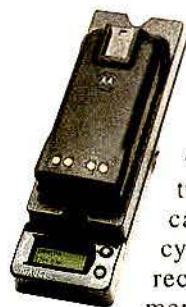
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CIRCLE (60) ON FAST FACT CARD

Battery gauge shows capacity check



The iGauge capacity check and readout system for the iCharge two-way radio battery chargers from **Advanced Charger Technology** features a user-friendly LCD, a capacity-check mode to cycle the battery once and a recondition mode to implement a triple-conditioning cycle to restore lost capacity. It attaches to any bay on the iCharge 6 or iCharge 6M units. The iCharge system features the enrev battery operating system software that uses real-time intelligence to monitor and measure the battery's condition and capacity as it is being charged.

CIRCLE (414) ON FAST FACT CARD

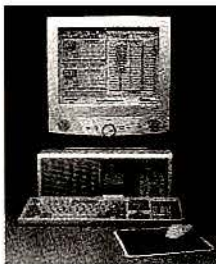
Paging encoder adds mail drop feature

Zetron has upgraded its model 61F network-access paging encoder with the addition of the "mail drop" feature. The encoder interfaces to almost any digital-paging transmitter to create a TNPP network node for encoding Flex and POCSAG. In private paging applications, such as manufacturing, the encoder can be used to monitor industrial controls and status levels.

CIRCLE (415) ON FAST FACT CARD

Voice recorder uses DVD storage media

The DVD voice recorder line from **Dynamic Instruments** is a part of the DI family. It provides an alternative in off-line storage capability. Each DVD drive can store more than 600 channel hours per 5.2GB disk. DVD media provide random access, resulting in specific search results in less than four seconds. The DI-936PRO2 DVD recorder is available with eight to 32 recording channels per chassis. The DI-939/E DVD recorder is available with 40 and 64 channel configurations. Scalability is achieved by additional systems, which are networked together to achieve integration of channels.



CIRCLE (416) ON FAST FACT CARD

Router works over multiple networks

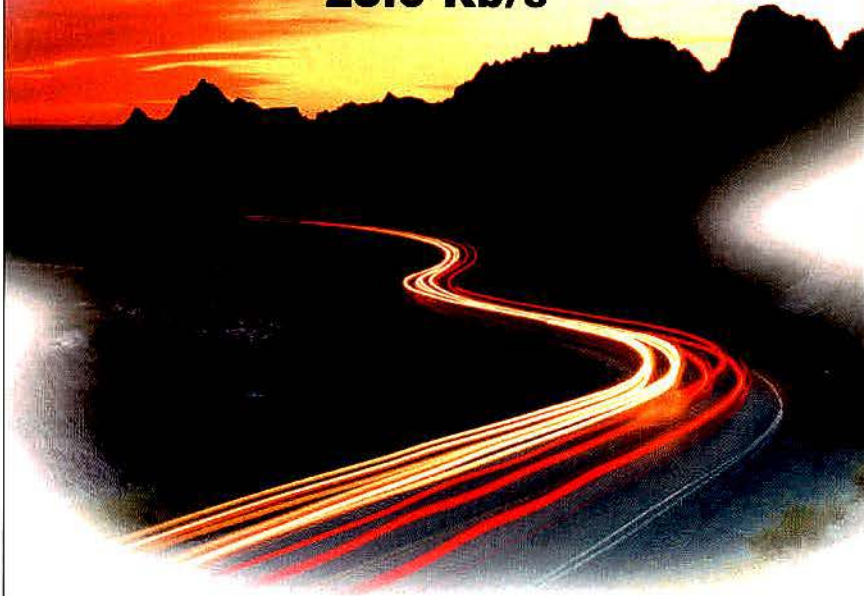
Padcom's Totalroom offers an intelligent network-routing platform for mobile vehicle and remote device communications. The platform sends and receives data over multiple, disparate networks dynamically. The architecture provides hardware and software required to manage connectivity to WANs and LANs. The product helps eliminate barriers of capital costs and spectrum availability. The platform

consists of an in-vehicle router and host software. Users can build a single logical network from two or more previously disparate networks. Customer information defines how the platform is configured and on what basis one network is selected over another.



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CIRCLE (30) ON FAST FACT CARD



Portable radio operates in lowband

Kenwood Communications' TK-190 public service radio is a 6W, 16-channel, VHF lowband portable. The portable features priority scan, a seven-character alphanumeric LCD and two-digit channel display, programmable keys and toggle switch. Designed by and for fire departments, utilities and transportation agencies, the TK-190 meets MIL-STD 810 C, D and E, including driven-rain specs. The portable features a weather-sealed internal microphone and is complemented by the KMC-25 noise-canceling speaker mic option. The radio has QT/DQT CTCSS tone/digital coded squelch, two-tone/DTMF decode and operator-selectable tone as standard. An intrinsically safe option is available for hazardous environments.

CIRCLE (418) ON FAST FACT CARD

Adapter bridges SMA, MMCX interfaces



The RSA-3408-1 SMA jack-to-MMCX plug adapter from RF Connectors suits frequencies as high as 6GHz. It features a gold-plated, machined brass body, gold

contacts and PTFE insulation. The knurled band on the body provides enhanced gripping for installation.

CIRCLE (419) ON FAST FACT CARD

Isolator offers low intermodulation



The model INA-0808 isolator from Narda operates over the 869MHz to 894MHz frequency range. Designed for maximum insertion

loss of 0.2dB, this isolator offers a minimum isolation of 25dB and a maximum VSWR of 1.2dB. Intermodulation is less than -110dBc, and the operating temperature range is -40°C to 60°C. The isolator measures 1.5" x 1.5" x 0.75" and is equipped with SMA female connectors.

CIRCLE (420) ON FAST FACT CARD

Submersible headset withstands 3m depths

Television Equipment Associates offers a combination of a low-power radio and high-noise headset, submersible to 3m. The radio/headset operates for 10 hours of constant use on batteries that recharge in three hours. Knobs control volume and channel selection; a touch switch provides PTT. Noise-attenuating earshells overcome high-ambient noise like engine noise. For voice communications, talk-through electronics open the mic circuit so the user can communicate without removing the headset. The boat crew radio headset has an adjustable headband so that it can be worn over various safety helmets.



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CIRCLE (62) ON FAST FACT CARD

AVL system adds new mapping features

Cimarron Technologies has added new features to the Skymark Vehicletracker. The GPS/AVL system operates over CDPD network or can be integrated with an existing two-way radio network. A mobile unit consisting of a GPS antenna and CDPD or RF modem is installed in each fleet vehicle. Using GPS, the mobile unit transfers the data from the vehicle to the Vehicletracker mapping software at the dispatch center. Dispatchers can moni-

tor speed, heading, direction, time, status and exact location of all vehicles 24 hours a day. The software is available in two formats: digital or database. A digital map is a scanned image of a paper map. Mapping features include daily report writing, compatible in a network environment, exact address lookup, alert of vehicles entering and exiting user-defined locations and communications via status text terminal.

CIRCLE (422) ON FAST FACT CARD

Radio offers P-25 trunking capability

The XTS-2500 digital portable radio from Motorola provides Project 25 digital trunking capability. The dual-band radio operates in the 800MHz and 700MHz bands. The radio provides a migration path for current analog customers who want to move their operations to a 9600-baud Astro 25 digital trunked system. The radio meets MIL 810 specifications. It is available in three models: one with basic features and functionality, another with a large display and limited keypad for greater functionality, and a third with a large display and full alphanumeric keypad for control of all the radio's capabilities. It features short-message capability, a new navigation key for user-friendly menu selection and a USB connector for data connectivity. The emergency button design and positioning on the top of the radio provide easy access and help prevent inadvertent activation.



CIRCLE (424) ON FAST FACT CARD

Internet protocol radio extends user access

Com-Net Ericsson Critical Radio Systems, with Catalyst Communications Technologies, has introduced the next generation of network access radio. The IP Radio extends the power of EDACS, Provoice and conventional radio communications across a LAN or WAN. IP Radio brings together PCs, land mobile radios and voice over IP technology to allow standard desktop computers on an existing LAN or WAN to transmit and receive voice messages to and from mul-

tipole field teams via the land mobile radio system. IP Radio allows users to change groups, make individual calls and see the name of the calling radio. The product gives PC users access to a centralized database of radio users that can be sorted by first name, last name, logical ID or department. A call history window provides the name of the calling party, the group or individual called, time, date and emergency indication.

CIRCLE (423) ON FAST FACT CARD

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CIRCLE (51) ON FAST FACT CARD

Modem transmits at 25.6kbps

Dataradio's GeminiPD is a 25.6kbps RF data modem designed exclusively for private radio networks. The modem uses dual receivers to decode messages simultaneously, providing performance in multipath and fading environments. The "parallel decode" (PD) technology, along with the DSP-based modem, produces fewer retries and effective throughput. Other features include an optional built-in GPS receiver, as many as 16 flash E²Prom-programmable channels with automatic channel selection and three RS-232 data ports with a built-in multiplexer. Out-of-band signaling via the dynamic bandwidth allocation protocol enables the modem to transmit GPS positions while conserving spectrum. DBA protocol supports AVL, report writing and other long-message applications through "reservations."

CIRCLE (425) ON FAST FACT CARD

Microwave analyzer offers group delay module



IFR Systems has added a new measurement capability to its 6840 series microwave system analyzer. The group delay module adds group-delay measurements and frequency modulation

for microwave test applications. All 6840 series models, with frequency ranges in combinations from 1MHz to 24GHz, can be upgraded with group delay (Option 22) module using an expansion slot inside the instrument. The group-delay range is from 1nsec to 10msec with a resolution of 0.1nsec and absolute accuracy of 0.5nsec. The analyzer is based on an architecture that includes a synthesized, low-phase noise signal source and a high dynamic range spectrum analyzer with a tuned receiver.

CIRCLE (426) ON FAST FACT CARD

Monitor offers multiple alarm routes

The Mini Mac monitoring system from Davicom Technologies offers monitoring, alarm and control functions. The system can be operated via PC terminal or DTMF telephone, and reporting of alarms can be made by telephone, pager, PC or fax. It offers programmable delays before action or return-to-normal condi-



tions and "virtual" inputs/relays for establishing conditional actions. It also offers eight metering inputs, 16 status inputs, two audio inputs and eight relays.

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CIRCLE (20) ON FAST FACT CARD

Ac panel uses silicon-diode system

The Apex series ac panel system from **Transtector Systems** is a modular power protection product that uses a silicon-diode system with a flexible power bus. The stacked-diode board design eliminates the lead lengths common to many types of individual suppressor components, increasing system efficiency. With

a plug-and-play backplane, the suppressor cards are easily changed or upgraded as power requirements change. Each hot-swappable suppressor card is self-contained and installed inside a lockable, non-metallic, NEMA-4X enclosure with a UL fire rating of 94-5V.

CIRCLE (428) ON FAST FACT CARD

Software provides real-time fleet locations

The VisionGEO Locator from **Vision Software** is a software application that provides dispatchers with a graphical display of real-time unit locations. VisionGEO integrates with computer-aided dispatch (VisionCAD) software and operates on a Windows NT

platform. The software allows dispatchers to automatically access the locations of units enabled with AVL to determine the positions of any hazards, fire hydrants or other significant landmarks near or at a caller's address.

CIRCLE (429) ON FAST FACT CARD

Trunking logic board supports Motorola ELP

The ST-865M6 Smartrunk II Omni logic board from **SmarTrunk Systems** is for the Motorola Entry Level Professional (ELP) series radios. The board is configured for easy, plug-in installation in the following models: PRO3150, CT250/450, P040/080 and GP308. The board offers a features set for large-fleet

dispatch and multisite roaming applications, including multiple channel banks, multiple PTT groups, multiple receive groups, Smartscan, positive radio kill, Turbo Speedial and PC programming with Pro-OSS (Professional series Optionboard Service Software).

CIRCLE (430) ON FAST FACT CARD

Aluminum tower mounts on vehicle



The model BD-60HD from **Aluma Tower** is a vehicle-mounted aluminum crankup tower. The tower telescopes to 60 feet and is designed to mount on a full-size van. These portable units are suitable for temporary emergency communications, two-way radio, trunking systems, site surveys, wireless data transfer and many other applications. The nested aluminum tower transports in a horizontal position. On site, the tower is easily tilted to the vertical position and telescoped to desired height. Units are available to 100 feet. They come with a tower, track and carriage.

CIRCLE (431) ON FAST FACT CARD

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CIRCLE (18) ON FAST FACT CARD

Michigan scanner law

I would like to take this opportunity to inform your readers of a law in Michigan that may affect those who travel with "police scanners."

Michigan Law MCL750.508 prohibits "equipping" a vehicle with any radio able to receive police frequencies. "Equipping" has been defined as "possession." According to the Michigan State Police (MSP) and most county prosecutors, you cannot even have a scanner in the trunk of your car, much less in the passenger compartment.

Michigan is one of only six states that restrict scanners in vehicles. Ham radio operators are exempt from anti-scanner legislation nationwide.

Michigan residents may apply for a scanner permit from the MSP; tourists may not. If you come to tour Michigan and bring a scanner, you will be considered to be a criminal as soon as you cross the border.

Why are your tourist dollars welcomed and not your hobby?

Help to effect a change of the law. A

protest of MCL750.508 has started. Call or write the Michigan Department of Tourism and the state of government. Express your concern over this law that associates you and your hobby with criminals.

For more information, visit Web site: www.scannerway.8m.com/letter.html. This site contains the current law, suggested changes and a plea for support.

Addresses for relevant Michigan government agencies are included on the site (at the bottom of the post).

—Mark Bajek
Westland, MI

MBajek000@msn.com

Look to ham radio operators

I enjoyed your article in this month's edition of *MRT* ("So Many People, So Few Jobs," *Editorial Forum*, July 2000) and can unfortunately see my predictions are coming sadly true. I told a few of my friends that soon there would be a real shortage of RF-type techs around, and they sort of laughed and said "Never happen." Well, as I see it, RF and telecommunications is sort of taking a back

seat to the "computer nerds." All kids of today hear about is the big money that gamers and Internet guys are making and ask, "Where is mine?"

I see one solution that might be of help to some: Why not have LMR and SMRs look at the local ham radio community to do joint ventures to help train those who are already interested in communications (who have showed it by getting their licenses)?

I don't know if you are a ham or not—I am and have been for some time and enjoy it quite a bit. Anyway, I think that could work out, especially in the framework of "Career Days," or "Job Day" (or whatever they call it these days) where you have a high school student come to work with you. Or allowing employees to give talks at local high schools to show the other side of things.

—Dennis Smith
Field engineer and contractor

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PEOPLE



Peters



Enockson



Kearns



Johnson

Changes at Sabre Communications, Sioux City, IA:

David J. Peters, controller, advances to chief financial officer. **Julie M. Enockson** departs John Deere North American Ag Marketing Center, Lenexa, KS, as marketing accountant to join Sabre as controller.

Kevin Kearns, manager of the King County, WA, Emergency Management Division, wins Schaumburg, IL-based Motorola's Danny Smith Award.

Robert C. Johnson joins Highpoint Tower Technology, Tampa, FL, as director of construction after serving as a consultant to Crown Castle Communications, Houston, and BellSouth Mobility.

Jim McMahon leaves Beckman Coulter, Fullerton, CA, as regional sales manager to join Geographic Data Technology, Lebanon, NH, as director of vertical sales.

Mark Borota, senior vice president for the Core Networks Group of Motorola's Global Telecom Solutions Sector, joins Boca Raton, FL-based NetSpeak's board of directors.

Paul Grove departs TIC United as president, Hutchinson/ Mayrath Division, Clay Center, KS, to join Rohn Industries, Peoria, IL, as vice president, tower division.

Larry Eveslage, national sales manager, is promoted to corporate vice president at NK Cables U.S.A., Irving, TX.

Lyle Gallagher, North Dakota state radio communications director, becomes president of the Association of Public-Safety Communications Officials International (APCO), South Daytona, FL.

Promotions at SCC Communications, Boulder, CO:

John Jarboe, vice president of engineering, advances to vice president of advanced technology. **Susan Cottingham**, director of software engineering, becomes vice president of software engineering.

Changes at Crown Castle International, Houston:

Stephen Schmitt departs Marconi PLC, London, as vice president of supply chain e-business to join Crown Castle as senior vice president. **Jerry Vogl**, vice president of information technology-U.S. operations, becomes vice president of new business integration.

Ihab Abu-Hakima exits Silicon Graphics Computer Systems, Mountain View, CA, as vice president to join Western Multiplex, Sunnyvale, CA, as vice president of worldwide marketing.

TRANSMITTER LOCATION



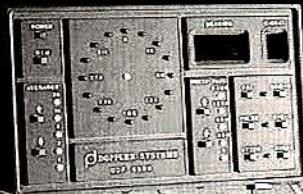
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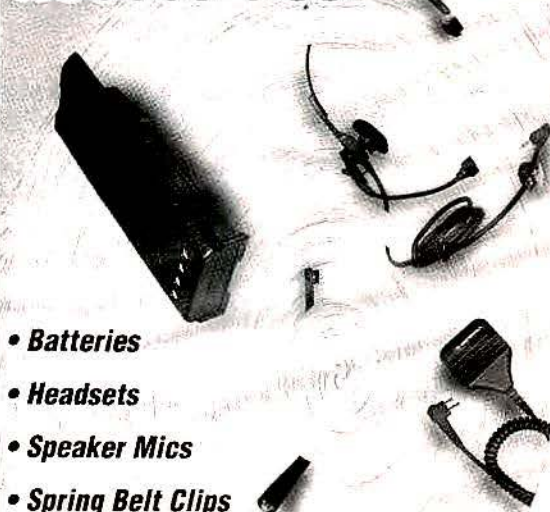
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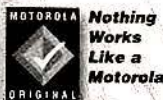
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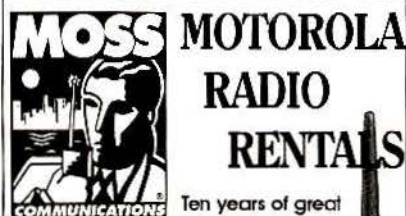
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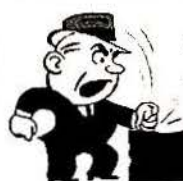
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Diversified Electronics	58	63	800-646-7278	Softwright.....	78	118	303-344-5486
DLC	22	25	800-421-3538	Survey Technologies, Inc.	78	119	503-848-8500
Doppler Systems, Inc.	69	50	480-488-9755	Telepath	74	109	510-656-5600
Duracomm Corp.	68	59	800-467-6741	Telepoint, Inc.	30	48	310-652-3666
Eagle Wireless International.....	53	68	281-538-6000	Telewave, Inc.	5	6	800-331-3396
EDX Engineering, Inc.	61	33	541-345-0019	Thunder Eagle	50	52	888-877-8022
E.F. Johnson	1	4	800-621-2945	Times Microwave Systems	55	53	203-949-8400
EPCOM	74	107	915-533-5119	Times Microwave Systems	57	56	203-949-8400
EML	73	103	615-771-2560	TPL Communications, Inc.	46	43	323-256-3000
Fiplex Communications, Inc.	62	60	305-884-8991	TX RX Systems Inc.	3	5	800-866-TXRX
Gentex Corp.	66	19	800-258-3554	Vega/Telex Signaling Products	10	9	800-752-7560
Hark Systems, Inc.	73	104	843-764-1560	VERTEX/YAESU USA	IFC	1	562-404-2700
Holzberg Communications, Inc.	74	106	973-389-9600	Vocom Products	75	112	800-872-6233
Huber + Suhner, Inc.	29	29	802-878-0555	WETEC	75	111	901-286-6275
ICOM America	IBC	2	425-450-6088	W & W Manufacturing.....	7	7	800-221-0732
I-Com Industry, Inc.	69	65	703-707-9094	Zetron, Inc.	35	34	425-820-6363
IDA Corporation	60	46	800-627-4432	Zetron, Inc.	71	100	425-820-6363

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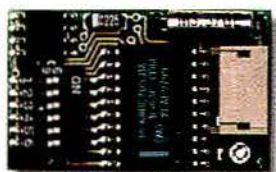
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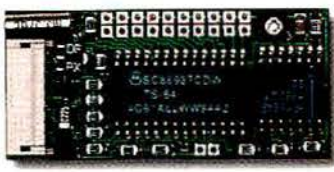

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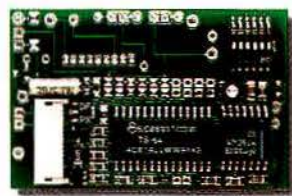
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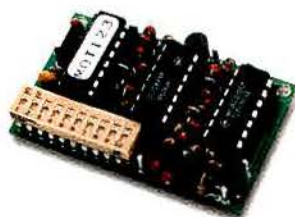
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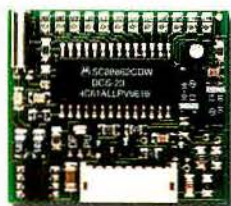
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